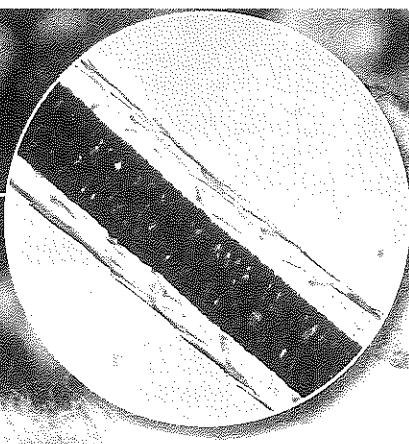
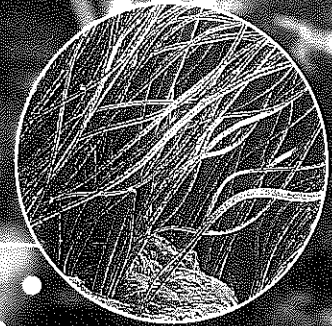


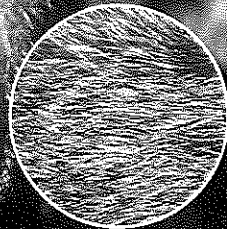
Individual hair
LM Magnification: 400×



Undercoat and hairs
SEM Magnification: 40×



Red fox fur



THEME FOCUS Energy and Matter
Mammals' metabolisms need large amounts of energy to sustain their body temperatures.

BIG Idea Mammals have evolved to have many adaptations for maintaining homeostasis and living in a variety of habitats.

Section 1 • Mammalian Characteristics

Section 2 • Diversity of Mammals

Section 1

Reading Preview

Essential Questions

- What are the characteristics of mammals?
- How do mammals maintain a constant temperature?
- How does respiration in mammals differ from that of other vertebrates?

Review Vocabulary

metabolic rate: the rate at which all the chemical reactions that occur within an organism take place

New Vocabulary

mammary gland
diaphragm
cerebral cortex
cerebellum
gland
uterus
placenta
gestation



Multilingual eGlossary

Mammalian Characteristics

Idea Mammals have two distinct characteristics: hair and mammary glands.

Real-World Reading Link Think about the characteristics of the other classes of vertebrates that you have studied. Think about how you are different from the animals in the other classes. The characteristics you have as a mammal allow you to carry out your daily life functions and activities.

Mammary Glands and Hair

Two characteristics that distinguish members of class Mammalia from other vertebrate animals are mammary glands and hair.

Mammary glands produce and secrete milk that nourishes developing young. Recall that if an animal has feathers, it is a bird. In a similar way, if an animal has hair, it is a mammal. As you can see on the evolutionary tree in **Figure 1**, mammals have their own branch labeled *hair and mammary glands*.

Functions of hair Mammals' hair has several functions, including:

1. **Insulation:** One of the most important functions of hair is to insulate against the cold. Mammals benefit from having fur or hair that traps their body heat and prevents it from escaping.
2. **Camouflage:** The striped coat of a Bengal tiger allows it to blend into its natural habitat—the jungle.
3. **Sensory devices:** In some cases, hair has been modified into sensitive whiskers. Seals use the whiskers on their snouts to track prey in murky water by sensing changes in water movements when a fish is nearby.
4. **Waterproofing:** You might know how cool it feels when you come out of a swimming pool on a hot day. As the water evaporates from your skin, your body loses heat. Many aquatic mammals, such as the sea otter shown in **Figure 2**, have hair that keeps water from reaching their skin. This helps them maintain their body temperature.

Figure 1 Hair and mammary glands are two characteristics that distinguish mammals from other vertebrates.

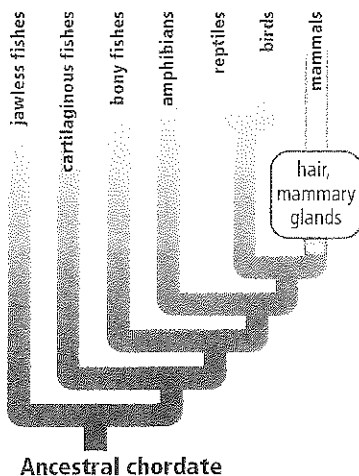
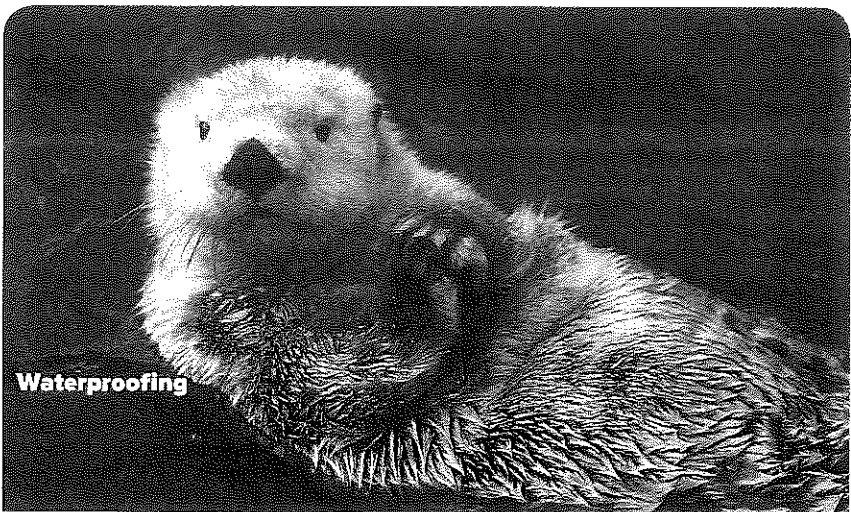
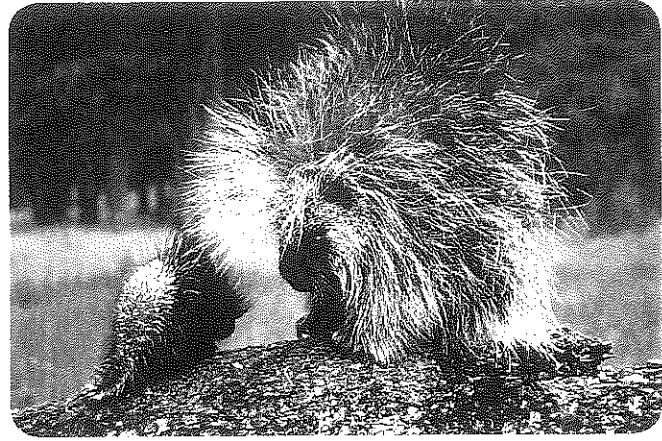


Figure 2 The hair covering this sea otter helps keep water from reaching its skin.






Signaling



Defense

5. Signaling: Hair can function as a signaling device. The white-tailed deer in **Figure 3** raise their tails, the undersides of which are white, when they run so that other deer can follow.
6. Defense: Hair also can function as a defense against predators. The porcupine in **Figure 3** has sharp quills, which are modified hairs, that are easily detached when the animal is threatened by a predator. The quills stick to and stab predators that touch the porcupine.

Structure of hair The hair in a bushy fox tail and the hair on your head contains a tough, fibrous protein called keratin, which is a protein that also makes up nails, claws, and hooves. A coat of hair usually consists of two kinds of hair, long guard hairs that protect a dense layer of shorter insulating underhair. The air trapped in the thick underhair layer provides insulation against the cold and retains body heat.

 **Reading Check Explain** why hair is important to mammals.

Other Characteristics

In addition to having hair and mammary glands, mammals share other characteristics. These include a high metabolic rate, which supports endothermy; specialized teeth and digestive systems; a diaphragm to aid in respiration; a four-chambered heart; and a highly developed brain.

Endothermy Mammals are endotherms, which means they produce their body heat internally. The source of body heat is internal, the result of heat produced by a high metabolic rate. Body temperature is regulated by internal feedback mechanisms that send signals between the brain and sensors throughout the body.

For example, when some mammals become warm as a result of exertion or because the air is warm, sweat glands in the skin are stimulated to secrete sweat that evaporates from the skin. As the sweat evaporates, it draws heat away from the body and cools it. When body temperature lowers, sweating stops. For other mammals that do not sweat, panting cools the body. You might have seen a dog panting in the summer heat. During panting, water evaporates from the mouth and nose. Because mammals can regulate their body temperatures internally to maintain homeostasis, they can live in a range of ecosystems from the frigid temperatures of polar regions to the sweltering heat of deserts and the tropics.

Figure 3

Left: The white hair on the tails of these deer signal them to follow each other as they run from predators.

Right: The quills of a porcupine are modified hairs that are used as protection from predators.

Study Tip

Prediction Preview this section by looking at the bold titles and the photos. Predict the distinguishing characteristics of mammals. Use the titles and photos to help anticipate how to take notes on this section.



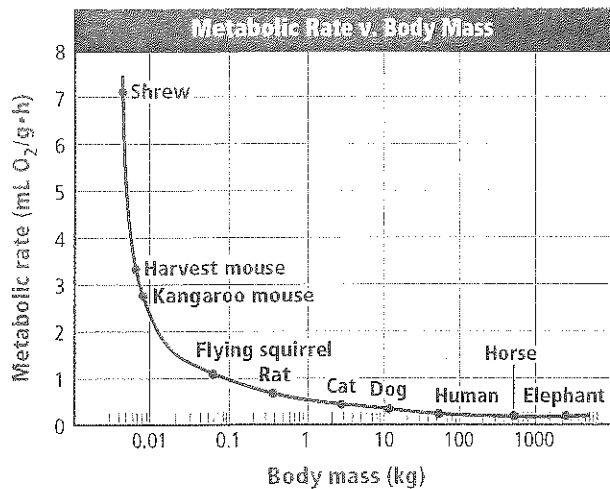


Figure 4 Due to their high metabolic rates, some small mammals, such as mice and shrews, must eat food masses that are equivalent to their body masses each day in order to maintain temperature homeostasis.

CAREERS IN BIOLOGY

Mammalogist The branch of biology that focuses on the study of mammals is mammalogy. A mammalogist might research the behavior, anatomy, or ecology of one or more species of mammals, or he or she can compare characteristics, such as digestion, in many species of mammals.

Feeding and digestion Maintaining an endothermic metabolism requires large amounts of energy. Mammals get the energy they need from the breakdown of food. Much of an endotherm's daily intake of food is used to generate heat to maintain a constant body temperature.

Examine the graph in **Figure 4**. The graph shows the relationship of a mammal's metabolic rate to its body mass. Small mammals, including shrews, bats, and mice, have high metabolic rates relative to their body mass. As a result, these small mammals must hunt and eat food almost constantly in order to fuel their metabolisms.

Trophic categories Mammalogists divide mammals into four trophic categories based on what they eat.

1. Insectivores, such as moles and shrews, eat insects and other small invertebrates.
2. Herbivores, such as rabbits and deer, feed on vegetation.
3. Carnivores, such as foxes and lions, mostly feed on herbivores.
4. Omnivores, such as raccoons and most primates, feed on both plants and animals.

A mammal's adaptations for finding, capturing, chewing, swallowing, and digesting food all influence the mammal's structure and life habits. The fibers of plants are more difficult to digest and take longer than the digestion of meat. As a result, mammals that eat plant material have a larger cecum and longer digestive tracts than those that eat meat, as shown in **Figure 5**.

Ruminant herbivores Cellulose, a component of the cell walls of plants, can be a source of nutrition and energy. However, the enzymes in the digestive system of mammals cannot digest cellulose. Instead, some herbivores have bacteria in the cecum, a pouch where the small intestine meets the large intestine. Other herbivores have bacteria in their stomachs that break down the cellulose and release nutrients the animals can use. These mammals, called ruminants, have large, four-chambered stomachs. Cattle, sheep, and buffalo are all ruminants. As a ruminant feeds, plant material passes into the first and second stomach chambers. Plants are partially digested by bacteria into a material called cud. The ruminant brings the cud back up into the mouth and chews the cud for a long period of time. This further crushes the grass fibers. Once the cud is swallowed, it eventually reaches the fourth chamber of the stomach where digestion continues.

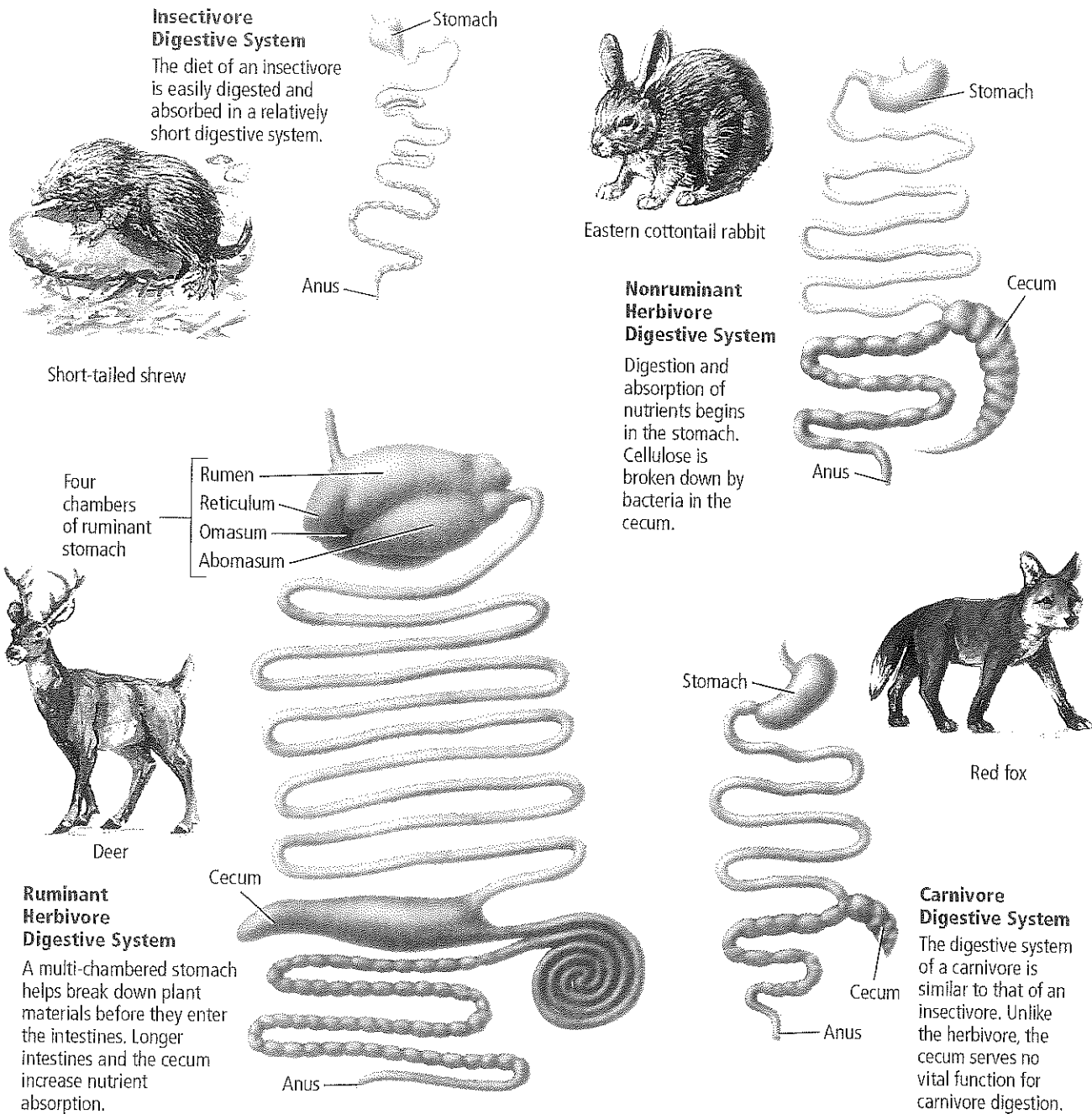


Reading Check Infer the type of relationship that exists between a ruminant and the bacteria in its stomach.

Visualizing the Digestive Systems of Mammals

Figure 5

The digestive systems of mammals are adapted to maximize the digestion and absorption of food. The protein consumed by carnivores and insectivores is readily digestible. Plant materials contain cellulose, which resists digestion, water, and some carbohydrates. Compare the structure of each digestive system below.



VOCABULARY

ACADEMIC VOCABULARY

Retain

to keep in possession or use

You can retain your teeth throughout adulthood by brushing and flossing.

Teeth In addition to adaptations of the digestive system, teeth, perhaps more than any other physical characteristic, reveal the life habits of a mammal. Generally, in fish and reptile species, all teeth in the mouth look very much alike. This is because these animals use all of their teeth in similar ways, for seizing prey or for tearing prey apart before swallowing. In contrast, mammals have different types of teeth that are specialized for various functions. Examine the four types of mammalian teeth—canines, incisors, premolars, and molars—as illustrated in

MiniLab 1

A fox's canines are long and sharp. Carnivores use canines to stab and pierce their prey. The canines of herbivores often are reduced in size. This is illustrated in the cow skull shown in **MiniLab 1**. The premolars and molars of carnivores are used to slice and shear meat from the bones of their prey, while crushing and grinding are the functions of premolars and molars in herbivores. The incisors of insectivores are long and curved, functioning as pincers in seizing insect prey. The chisel-like incisors of beavers are modified for gnawing. Because the teeth of mammals reflect their feeding habits, biologists can determine what a mammal eats by examining its teeth. Complete **MiniLab 1** to see what inferences you can make about a mammal's diet based on its teeth.

Excretion The kidneys of mammals excrete metabolic wastes and maintain the homeostatic balance of body fluids. Kidneys filter urea, an end product of cellular metabolism, from the blood. Mammalian kidneys excrete or retain the proper amount of water in body fluids as well. Kidneys enable mammals to live in extreme environments, such as deserts, because they can control the amount of water in body fluids and cells.

MiniLab 1

MiniLab

Compare Mammalian Teeth

How are the teeth of mammals specialized?

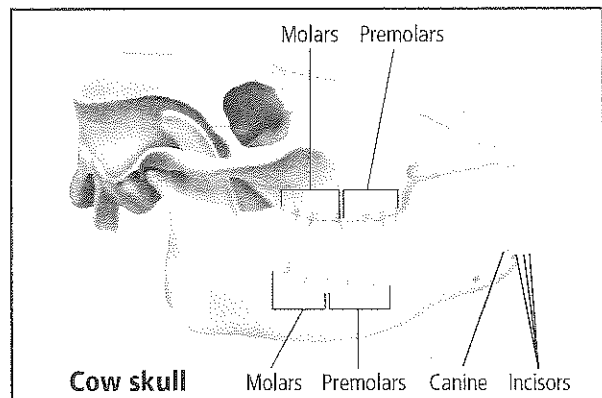
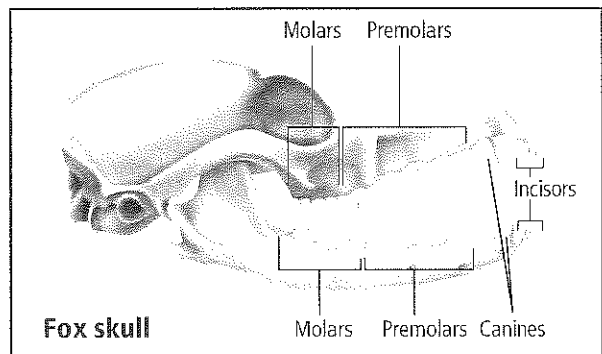
Explore how the teeth of different mammal species are related to their diets.

Procedure

1. Read and complete the lab safety form.
2. Observe **teeth from the skulls of different mammal species**.
3. List the similarities and differences among the teeth of the different mammal species.

Analysis

1. **Infer** the function of each type of tooth based on its shape.
2. **Identify** the type of tooth common to all of the mammals that you have studied.
3. **Describe** how each mammal that you have studied uses its teeth to obtain and ingest food.
4. **Explain** how scientists might use the differences in mammalian teeth to classify mammals.



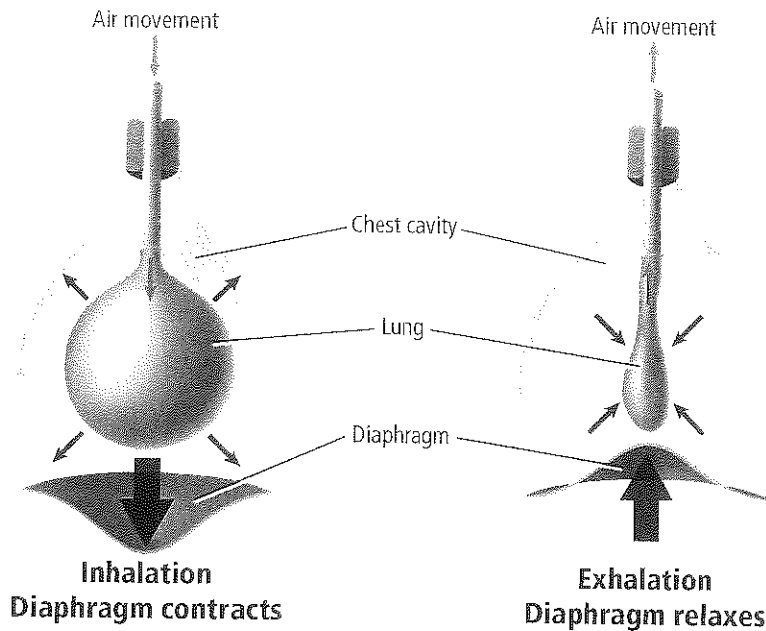


Figure 6 The flask with the balloon is an analogy of how the diaphragm aids breathing in mammals.

Describe what happens to the chest cavity as the diaphragm contracts and relaxes.

Respiration The food a mammal eats is used to maintain high energy levels. High levels of oxygen also are required to maintain a high level of metabolism. Oxygen is taken into the lungs of mammals during respiration. Although other animals, such as birds and reptiles, have lungs, mammals are the only animals that have a diaphragm. A **diaphragm** is a sheet of muscle located beneath the lungs that separates the chest cavity from the abdominal cavity where other organs are located. As the diaphragm contracts, it flattens, causing the chest cavity to enlarge, as shown in **Figure 6**. Once air enters the lungs, oxygen in the air moves by diffusion into blood vessels. When the diaphragm relaxes, the chest cavity becomes smaller and air is exhaled.

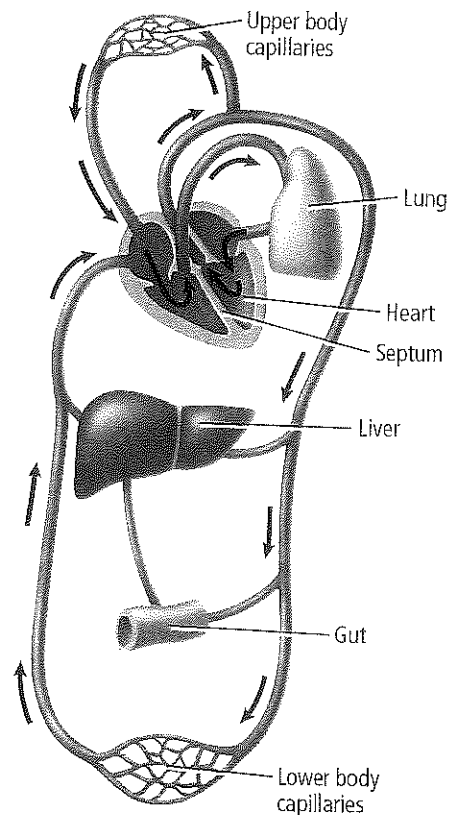
Reading Check Describe how the respiratory system of mammals is different from other animals.

Circulation Once oxygen is in the blood, vessels carry it to the heart, which pumps it out to the body. Like birds, mammals have a four-chambered heart. Also as in birds, oxygenated blood is kept entirely separate from deoxygenated blood in mammals. This is illustrated in **Figure 7**. Because most mammals are physically active and all are endotherms, they require a consistent supply of nutrients and oxygen to maintain homeostasis. Keeping oxygenated and deoxygenated blood separate makes the delivery of nutrients and oxygen more efficient.

Connection to Physics The circulatory system of a mammal also functions to help maintain a constant internal temperature. When body temperature increases, the blood vessels near the surface of the skin dilate, or expand, and deliver more blood than usual. Heat moves from the blood to the surface of the skin by conduction. At the skin's surface, heat is lost from the body by radiation and the evaporation of sweat. When body temperature decreases, blood vessels near the surface of the skin contract and do not deliver as much blood as usual. This action reduces the loss of body heat.

Personal Tutor

Figure 7 The circulatory system of mammals has a four-chambered heart that keeps oxygen-rich and oxygen-poor blood separate. Oxygen-rich blood is represented by the color red, while oxygen-poor blood is the color blue.



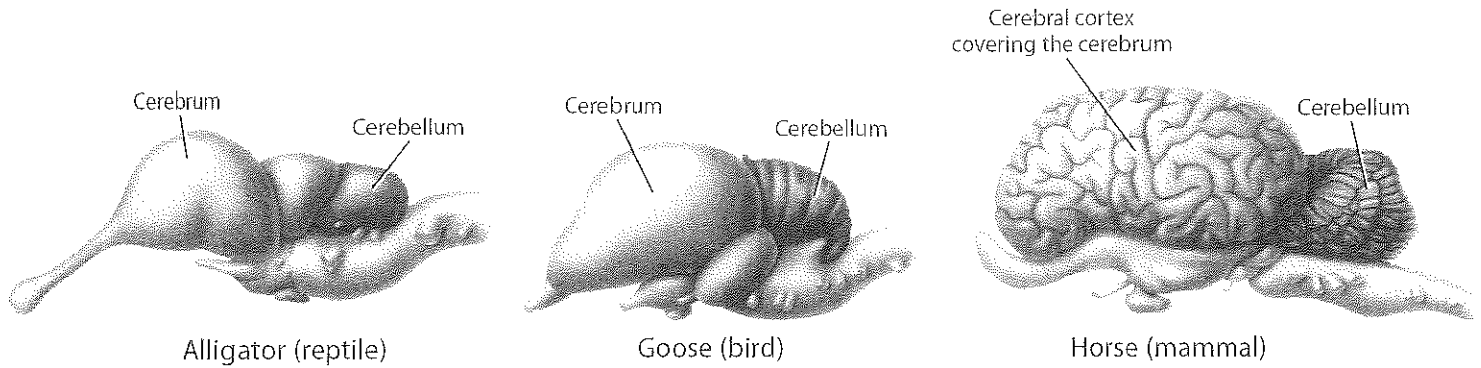


Figure 8 The cerebral cortex is the most complex part of the brain and is the part that has increased in size and changed most during the course of vertebrate evolution.

The brain and senses Mammals have highly developed brains, especially the cerebrum. The **cerebral cortex**, shown in **Figure 8**, is the highly folded outer layer of the cerebrum. The foldings allow the brain to have a larger surface area for nerve connections while allowing it to still fit inside the skull. The cerebral cortex is responsible for coordinating conscious activities, memory, and the ability to learn.

Another area of the mammalian brain that is well-developed is the cerebellum. The **cerebellum** is responsible for balance and coordinating movement. Compare the size and structure of the cerebellums of a reptile, a bird, and a mammal that are shown in **Figure 8**. A well-developed cerebellum allows an animal to have precise motor movements and to make complex movements in three dimensional space.

Complex behavior The mother fox on the opening page of the chapter will teach her young to hunt. Because mammals can learn and teach their young survival skills, they have an increased chance of survival. Mammals can carry out complex behaviors, such as learning and remembering what they have learned. Many mammals can get information about their environment and retain it. This information can then be used later. For example, mice that have had a chance to explore a habitat are able to avoid predators better than mice that have not had a chance to explore and learn about the same habitat.

Senses The importance of the senses varies from one group of mammals to the next. In some mammals, such as humans, vision is extremely important, while hearing is most important to mammals such as bats. Bats produce high-frequency sounds that bounce off objects and return to them. In this way a bat can detect objects in its path. This process is called echolocation. If you have seen how a dog sniffs people and objects in its surroundings, you recognize the importance of the sense of smell to this mammal. In some cases, a dog's sense of smell is one million times more sensitive than a human's sense of smell.

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Sense

Science Usage: a specialized animal function that involves a sense organ and a stimulus
Dogs use their sense of smell to get information about their environments.

Common Usage: an intended meaning

As I read the paragraph, I tried to get a sense of the main idea.




Reading Check Describe the advantage of having folds in the outer layer of the cerebral cortex using an analogy.



Glands A system of glands secretes a variety of fluids that helps to regulate a mammal's internal environment. A **gland** is a group of cells that secrete fluid to be used elsewhere in the body. Sweat glands help maintain body temperature. Mammary glands produce and secrete milk that nourishes developing young. Milk contains water, carbohydrates in the form of the sugar lactose, fat, and protein. The proportion of these nutrients differs according to species.

Examine **Table 1** to see the proportions of nutrients in the milk of various mammals. The proportion of nutrients is highly variable among different species of mammals. For example, fat amounts can range from one percent to 50 percent. Aquatic mammals, which use a layer of fat to help keep warm, usually have the highest percent of fat in their milk.

Scent glands produce substances that mammals use to mark their territories or attract mates. Oil glands in the skin maintain the quality of the animal's hair and skin. Other glands produce hormones that regulate internal processes, such as growth and release of eggs from ovaries.

 **Reading Check** **Explain** why the fat content in milk would be higher in aquatic mammals.

Reproduction In mammals, the egg is fertilized internally. In most mammals, development of the embryo takes place in the female uterus. The **uterus** is a saclike muscular organ in which embryos develop. In most mammals, the developing embryo is nourished by the **placenta**, an organ that provides food and oxygen and removes waste from the developing young. The amount of time the young stay in the uterus before they are born is called **gestation**. Gestation periods in mammals vary by species, the shortest being that of the Virginian opossum which can be only 12 days. The longest gestation period occurs in the African elephant, which is an average of 660 days and can be as long as 760 days. In general, the larger the mammal, the longer the gestation period. After birth, the offspring of mammals drink milk for nourishment from the mother's mammary glands.

VOCABULARY

gestation

Gestation

gest- from the Latin word *gestare*, meaning *to bear*

-ation suffix; from Latin meaning *action or process*

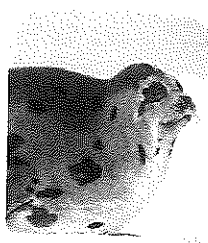
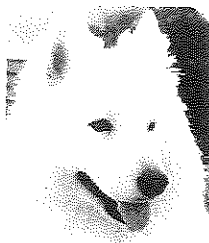
Table 1

Proportion of Nutrients in the Milk of Mammals



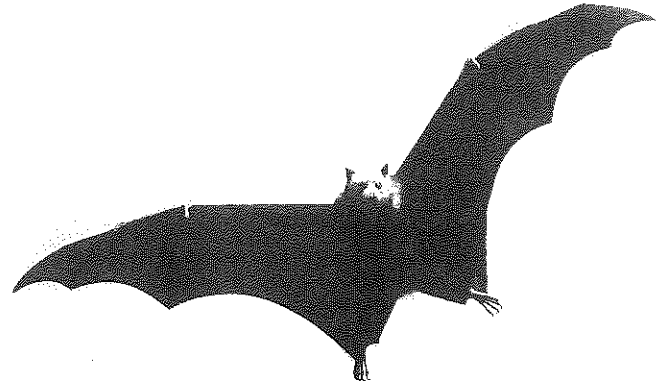
Interactive Table

Nutrient	Dog	Dolphin	Harp Seal	Rabbit	Zebra
Water	76.3	44.9	43.8	71.3	86.2
Protein	9.3	10.6	11.9	12.3	3.0
Fat	9.5	34.9	42.8	13.1	4.8
Sugar	3.0	0.9	0.0	1.9	5.3





Limbs used for digging and burrowing



Limbs used for flying

Figure 9

Left: The mole has powerful, short forelimbs that are adapted to digging and burrowing in the ground.

Right: The bat can fly with thin membranes spread between the elongated arm and hand bones.

Movement Mammals must find food, shelter, and escape from predators. They have evolved a variety of limb types that enable them to carry out these essential behaviors. Some mammals, such as coyotes and foxes, run. The cheetah, which is the fastest land mammal, can reach speeds as fast as 110 km/h.

Other mammals, such as kangaroos, leap. Some mammals, including dolphins, swim. Bats are the only mammals that fly. The structure of the skeletal and muscular systems in animals reflects the type of movement that an animal uses. Examine **Figure 9**, which shows the forelimbs of a mole and those of a bat. How does the structure of these limbs reflect the habitat and behavior of these animals?

Section 1 Assessment

Section Summary

- Mammals are successful in a wide variety of habitats.
- Mammals have specialized teeth that are adapted to their diets.
- Respiratory, circulatory, and nervous systems have complex adaptations that enable mammals to have the extra energy they need and to maintain homeostasis.
- Mammals have internal fertilization and, in most mammals, offspring develop within the female uterus.

Understand Main Ideas

1. **Identify** two characteristics unique to mammals.
2. **Explain** how mammals maintain a constant body temperature.
3. **Classify** the mammals that live in your area as herbivores, carnivores, omnivores, or insectivores.
4. **Summarize** how the respiratory and circulatory systems of mammals work together to enable mammals to have high energy levels.
5. **Compare and contrast** how respiration occurs in mammals to respiration in birds.

Think Critically

6. **Hypothesize** While working at an excavation site, an archeologist finds an intact skull fossil, including the teeth, of a mammal. Why are the teeth important to the archeologist?

MATH in Biology

7. Suppose a hare spotted a coyote and tried to run away. Coyotes can run at a speed of 70 km/h. Hares can run at a speed of 65 km/h. How far could the hare run before the coyote catches up? Assume that the hare is 25 m from the coyote.

©Justus de Cleveland/Imagebroker/Corbis; (f)Ewen Charlton/Getty Images

Section 2

Reading Preview

Essential Questions

- What are the characteristics of mammals in each of the three subgroups of living mammals?
- What are the adaptations that contribute to the diversity of mammals and enable them to live in a variety of habitats?
- How might mammals have evolved?

Review Vocabulary

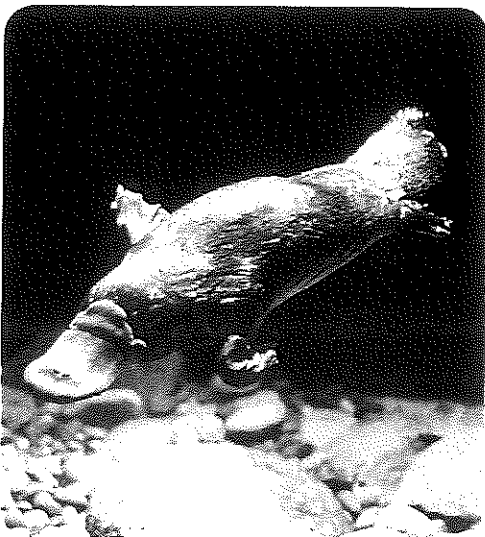
chromosome: cell structure that carries genetic material that is copied and passed from generation to generation of cells

New Vocabulary

monotreme
marsupial
placental mammal
therapsid

 Multilingual eGlossary

Figure 10 The echidna, like the duck-billed platypus, is an egg-laying mammal. Once an egg hatches, the offspring receive nourishment from the mother's mammary glands.



Duck-billed platypus

Diversity of Mammals


Key Idea Class Mammalia is divided into three subgroups based on reproductive methods.

Real-World Reading Link Think about the mammals that you see every day, such as dogs or squirrels. They are only a small part of the 4500 living species of mammals found on Earth. Scientists have developed zoos and wild animal parks that offer opportunities to learn about and enjoy the great variety of mammal species found in the world today.

Mammal Classification

Class Mammalia is divided into three subgroups based on methods of reproduction—monotremes, marsupials, and placental mammals.

Monotremes The animal shown in **Figure 10** with its duck bill and webbed feet might not look like any mammal you have seen. However, it has hair and mammary glands, which makes it a mammal. The duck-billed platypus is a monotreme that lays eggs similar to those of reptiles. **Monotremes** are mammals that reproduce by laying eggs. The only other living monotremes besides the duck-billed platypus are echidnas. An adult echidna is shown in **Figure 10**. Both the duck-billed platypus and the echidna only live in Australia, Tasmania, and New Guinea. Besides laying eggs, other unique features of these mammals include reptilian bone structure in the shoulder area, lower body temperature than most mammals, and a unique mix of chromosomes with characteristics similar to both mammals and reptiles.

 **Reading Check** Identify how monotremes are different from other subgroups of mammals.



Echidna





❖ **Figure 11** Opossums are the only marsupials in North America. Most opossums spend much of their time in the trees.

❖ **Figure 12** The cuscus is a nocturnal marsupial that is found in northern Australia and New Guinea. The red kangaroo has a development period of only 33 days, after which the newborn begins nursing in the pouch.



Cuscus

Marsupials Pouched mammals that have a very short gestation period are **marsupials**. Immediately following birth, the offspring crawl into a pouch made of skin and hair on the outside of the mother's body. Within the pouch, the offspring continue development while being nourished by milk from the mother's mammary glands. In some species of marsupials, offspring are born and crawl into the mother's pouch only eight days after fertilization occurs.

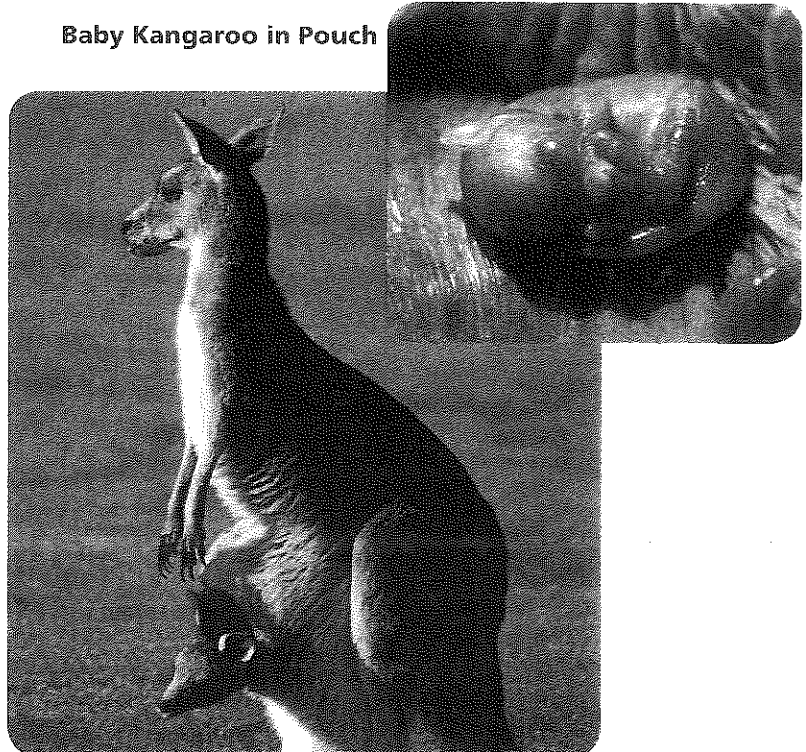
The only North American marsupial is the opossum, shown hanging by its tail in **Figure 11**. Other marsupials include the koala, wallaby, kangaroo, and cuscus, some of which are shown in **Figure 12**. Australia and its nearby islands are home to most marsupials.

Connection to Earth Science Why marsupials are limited mostly to Australia is still a subject for debate among scientists. One theory, based on fossil evidence, is that marsupials originated in North America, then spread to South America and Europe while the continents were still connected as one giant landmass. From South America, marsupials moved across Africa to Antarctica then to Australia. Then, about 200 million years ago, the continents separated due to the movement of Earth's tectonic plates. This isolated the ancestors of today's marsupials to Australia and nearby islands.

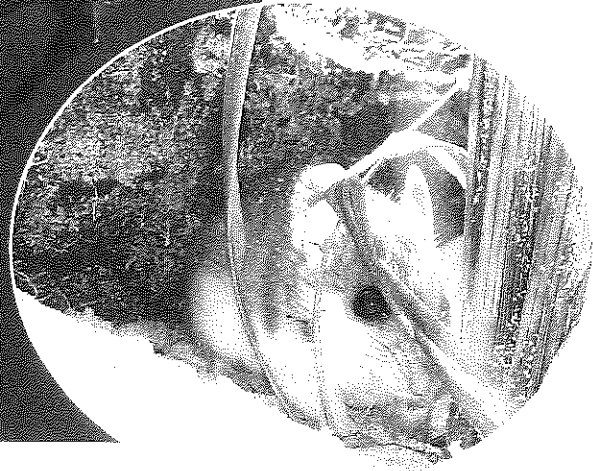
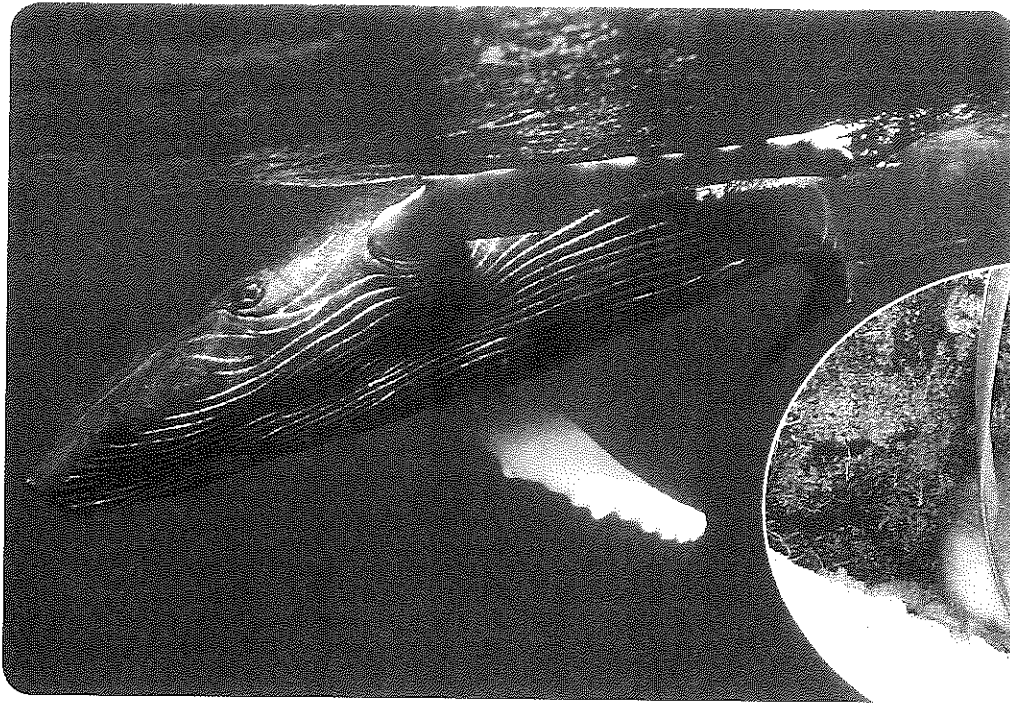
Australian marsupials thrived because they were isolated from competing placental mammals. In North and South America, however, placental mammals had competitive adaptive advantages. For example, placental mammals evolved highly social behavior, had more variety in food sources, and evolved greater diversity in form and function than marsupials.

Marsupials in Australia and New Guinea fill the niches occupied by placental mammals elsewhere in the world. For example, kangaroos are the grazers in Australia. They fill the niche that deer, antelope, and buffalo fill in other areas of the world.

Baby Kangaroo in Pouch



Kangaroo




Humpback whale

Placental mammals Most mammals living today, including humans, are placental mammals. **Placental mammals** have a placenta, the organ that provides food and oxygen to and removes waste from developing young. Placental mammals give birth to young that do not need further development within a pouch.

Placental mammals are represented by 18 orders. Some orders are represented only by a few species. For example, there are only two species of flying lemurs in order Dermoptera. The armadillo, a termite-eating mammal found in Africa, is the only species in its order. Other orders, such as Rodentia, which includes squirrels and rats, have almost 2000 species. Sizes of placental mammals range from 1.5 g to 100,000 kg, as shown in **Figure 13**. Placental mammals range from marine dolphins with adaptations for swimming to moles adapted to subterranean life and bats equipped with wings and ultrasonic echolocation for flying in the dark. **Table 2** on page 894 describes some of the different orders of placental mammals.

Scientists have hypothesized several reasons why there are greater numbers and kinds of placental mammals compared to marsupials. One hypothesis is that marsupial young must cling to their mother's fur at birth. Limbs, therefore, are limited in their ability to evolve into structures such as the flippers and wings of some placental mammals. Another hypothesis that explains the success of placental mammals points out that the cerebral cortex of placental mammals is larger and more complex than that of marsupials. This might be due to the more stable, oxygen-rich environment they experience inside the uterus. According to this hypothesis, this might have enabled placental mammals to develop more complex social behaviors that led to their success.

 **Reading Check Identify** how placental mammals differ from marsupials.

Beach mouse

Figure 13

The humpback whale, weighing 100,000 kg, is one of the largest mammals. This beach mouse, weighing 10 g, is one of the smallest mammals.

FOLDABLES

Incorporate information from this section into your Foldable.



Virtual Lab



Launch Lab

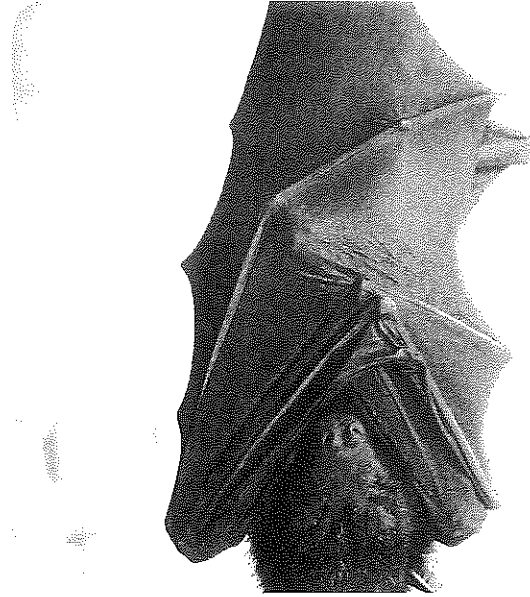
Review Based on what you have read about mammal classification, how would you now answer the analysis questions?





Order Insectivora—shrew

• **Figure 14** Shrews are members of order Insectivora. The flying fox is a bat that is a member of order Chiroptera.



Order Chiroptera—flying fox

VOCABULARY

Modify

to make changes that result in a new purpose

The wings of a bat are modified forelimbs for flying.

• **Figure 15** Golden lion tamarins are omnivores that live in the coastal forests of Brazil. **Identify other animals that are members of order Primates.**



Order Insectivora As the name implies, these mammals' main food source is insects. The shrew, shown in **Figure 14**, is an insectivore, as are hedgehogs and moles. Members of order Insectivora usually are small and have pointed snouts that allow them to capture insects easily. Shrews include the smallest of all mammals. Shrews can be found in almost all parts of the world and spend most of their lives underground.

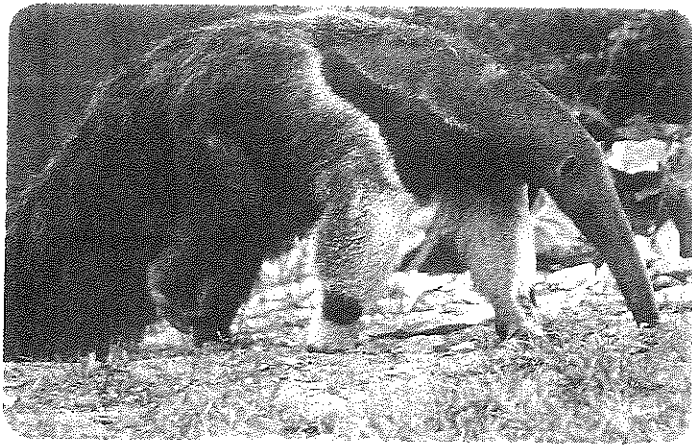
Order Chiroptera There are about 925 species in order Chiroptera (ky RAHP ter uh), all of which are bats. As mentioned previously, bats are the only mammals that truly can fly. Their wings are thin membranes supported by modified forelimbs. Bats feed on a variety of foods. Some eat insects, some eat fruit, and others feed on blood. The most common North American bat is the little brown bat which you might have seen swooping and darting at dusk to catch insects. The flying fox, shown in **Figure 14**, is the largest of all bats. It lives in tropical regions worldwide and feeds on fruit.

Order Primates Monkeys, apes, and humans are all examples of primates. Primates' brains, with large cerebral hemispheres, are the most developed brains of all mammals. Most primates are tree dwellers. This leads scientists to hypothesize that the need to perform complex movements while in trees, such as those involved in capturing food and avoiding enemies, led to advances in the brain structure of primates. Primate forelimbs often are adapted for grasping and most have nails instead of claws. The golden lion tamarin in **Figure 15** is grasping with its hands the branch on which it is sitting.

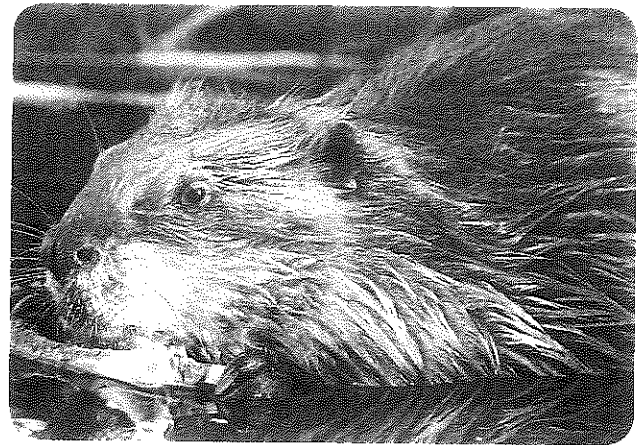
Order Xenarthra Animals in order Xenarthra (zen AR thra) either have no teeth or have simple, peglike teeth. Anteaters, like the one shown in **Figure 16**, are toothless. Anteaters have a spiny tongue and sticky saliva that allow them to easily capture ants and termites in their nests. Sloths and armadillos both have peglike teeth. Sloths mostly feed on leaves, and armadillos feed on insects. Most mammals in this order live in Central America and South America with the exception of the armadillo, which also can be found in the southern United States.

(t) Ivan Kuzmin/Stock/Getty Images; (tr) Thomas Hawk/Getty Images; (b) Juniors Bildarchiv GmbH/Alamy





Giant anteater



Beaver

Order Rodentia The gnawing mammals in order Rodentia, called rodents, include the beaver, which is shown in **Figure 16**, rats, woodchucks, marmots, squirrels, hamsters, and gerbils. Rodents make up nearly 40 percent of all mammalian species. Two pairs of razor-sharp incisor teeth continue to grow throughout the life of a rodent. They use their sharp teeth to gnaw through wood, seed pods, or shells to get food. The ability of rodents to invade all land habitats and their successful reproductive behavior have made them ecologically important in all terrestrial ecosystems.

Order Lagomorpha Like rodents, members of the the order Lagomorpha—rabbits, pikas, and hares—have long sharp incisors that continue to grow. Lagomorphs also have a pair of peglike incisors that grow behind the first pair. These mammals are herbivores that eat grasses, herbs, fruits, and seeds. The pika shown in **Figure 17** lives in high latitude or high altitude environments in which the ground is covered with snow for parts of the year. The grasseaters adapt to these conditions by harvesting grass during the warm months and storing it. The pikas then eat the grass during the winter when no fresh vegetation is available.

Order Carnivora You might have a pet dog or cat. It, along with wolves, bears, seals, walruses, coyotes, skunks, otters, minks, and weasels, belongs to the order Carnivora. All of these carnivores are predators with teeth adapted to tearing flesh. The lion, shown in **Figure 17**, feeds on antelope, giraffes, and even crocodiles. After she captures her prey, she uses her incisors to tear off chunks of meat.

◀ **Figure 16** The giant anteater, the largest anteater, is found throughout Central and South America. The second largest rodent is the beaver, weighing as much as 80 kg.

Describe the characteristics of members of order Xenarthra.

VOCABULARY

WORD ORIGIN

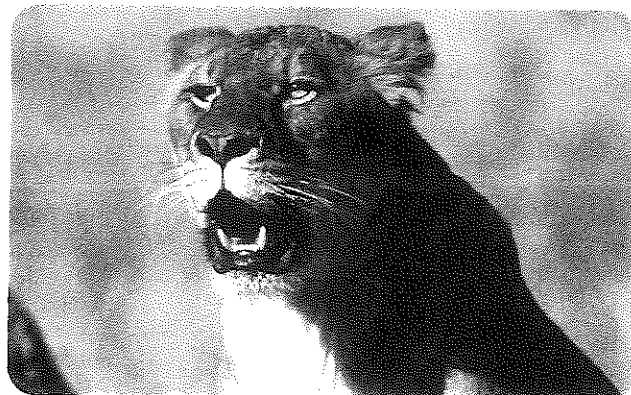
Lagomorpha

lago- from the Greek word *lagos*, meaning *hare*
-morph, from the Greek word *morphe*, meaning *form*

◀ **Figure 17** The American pika can be found in alpine regions of the western U.S. and southwestern Canada. The lion uses her canines to stab and pierce her prey.



Pika



Lion





Figure 18 The trunk of an elephant is called a proboscis. Trunks are unique to members of order Proboscidea.

Order Proboscidea Elephants are the largest living land mammals. They have flexible trunks adapted to gathering plants and taking in water. Two upper incisors are modified as tusks for digging up roots and tearing bark from trees. Some elephants are trained to help lift heavy objects. The elephant shown in **Figure 18** is helping remove debris that washed ashore during a tsunami in Indonesia on December 26, 2004. Ancient mastodons and mammoths are the extinct relatives of today's African and Asian elephants.

Order Sirenia Manatees and dugongs are members of the order Sirenia. They are large, slow-moving mammals with big heads and no hind limbs. Their forelimbs are modified into flippers that aid in swimming. These animals are herbivores, feeding on seagrasses, algae, and other aquatic plants. Depending on their size, manatees, shown in **Figure 19**, can consume as much as 50 kg of vegetation per day. Sirenians can be found cruising the surface of warm tropical rivers and lagoons. Because they are so slow and prefer the surface of the water, they often are injured or killed by the propellers of speedboats.

Order Perissodactyla These hoofed mammals include horses, zebras, and rhinoceroses. Members of this order have an odd number of toes, either one or three on each foot. These mammals are herbivores and have teeth that are adapted for grinding plant material. Perissodactyls can be found on all continents except Antarctica.


 **Reading Check** Compare placental mammals using **Table 2**.

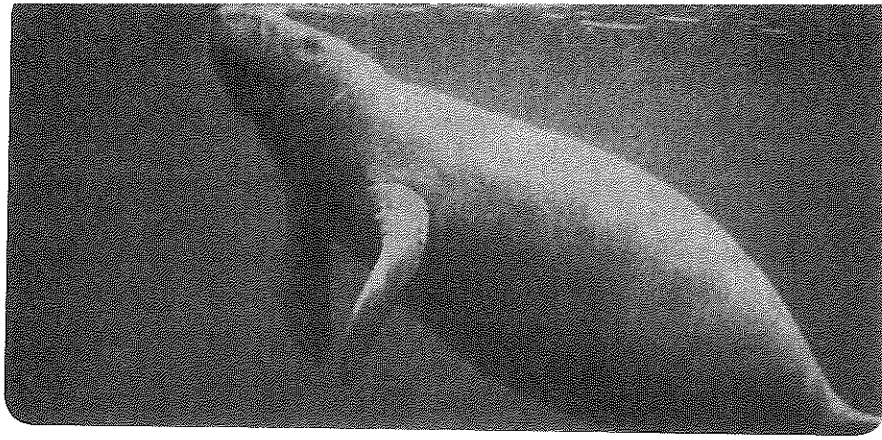
Table 2

Orders of Placental Mammals

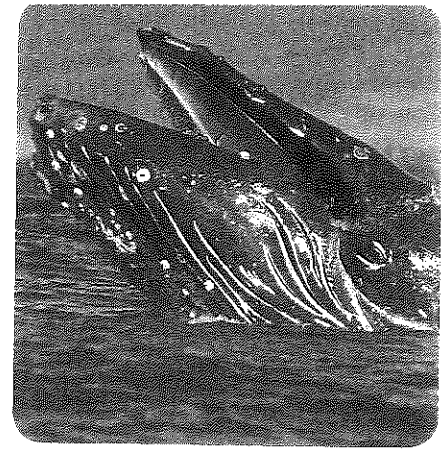


Interactive Table

Order	Example	Characteristics
Insectivora	Shrews, hedgehogs, moles	Pointed snouts, smallest mammals, live underground, insect-eaters
Chiroptera	Bats	Nocturnal, use sonar, adapted to flight, fruit and insect-eaters
Primates	Monkeys, apes, humans	Binocular vision, large brains, most are tree-dwellers, opposable thumb
Xenarthra	Anteaters, sloths, armadillos	Toothless or peg-like teeth, insect-eaters
Rodentia	Beavers, rats, woodchucks, marmots, squirrels, hamsters, and gerbils	Sharp continuously growing incisor teeth, plant-eaters
Lagomorpha	Rabbits, pikas, hares	Back legs longer than front legs, adapted to jumping, incisors that continually grow, herbivores
Carnivora	Dogs, cats, wolves, bears, seals, walruses, coyotes, skunks, otters, minks, and weasels	Teeth adapted to tear flesh, meat-eaters
Proboscidea	Elephants	Long trunks, incisors become long tusks, largest land animal
Sirenia	Manatees and dugongs	Slow moving, big heads, no hind limbs, adapted to aquatic environment
Perissodactyla	Horses, zebras, rhinoceroses	Hoofed, odd number of toes, plant-eaters
Artiodactyla	Deer, cattle, pigs, hippopotamuses	Hoofed, even number of toes, plant-eaters that chew cud
Cetacea	Whales, dolphins, porpoises	Front limbs that are flippers, no hind limbs, nostril forms a blowhole



Manatee



Humpback whale

• **Figure 19** The West Indian manatee is endangered. Wildlife managers help rescue manatees that have been injured by boat propellers. The baleen of a whale is similar to a sieve.

Order Artiodactyla Members of the order Artiodactyla also are hoofed mammals. They differ from perissodactyls in that they have an even number of toes, either two or four, on each limb. Deer, antelopes, cattle, sheep, pigs, goats and hippopotamuses are all artiodactyls. Many cattle, sheep, and deer have horns or antlers. Mammals in this order are herbivorous and most chew cuds as part of their digestive processes.

Order Cetacea Whales, dolphins, and porpoises have front limbs modified into flippers that aid in swimming. They have no hind limbs and the tail consists of fleshy flukes. Nostrils are modified into a single or double blowhole on top of the head. Except for a few muzzle hairs, their bodies are hairless. Some whales are predators. Others, like the blue whale, have a specialized structure inside their mouths called a baleen that is used to filter plankton for food. The baleen of a humpback whale is shown in **Figure 19**.

DATA ANALYSIS LAB 1

Based on Real Data*

Analyze and Conclude

How does boat noise affect whales? Killer whales might coordinate their cooperative hunting and other social behavior with certain calls that have meaning to the pod, or group of whales with which they travel. The number of boats in the area of study increased by about five times from 1990–2000.

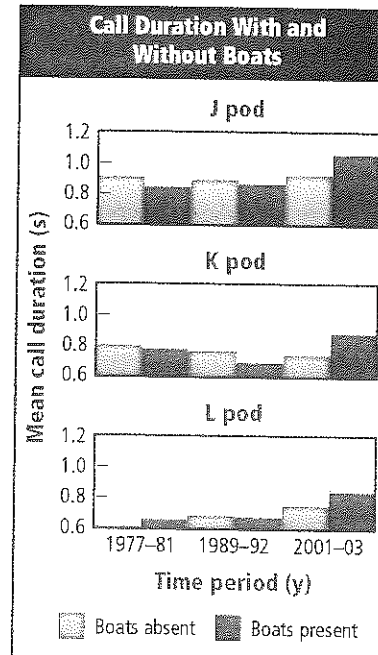
Data and Observations

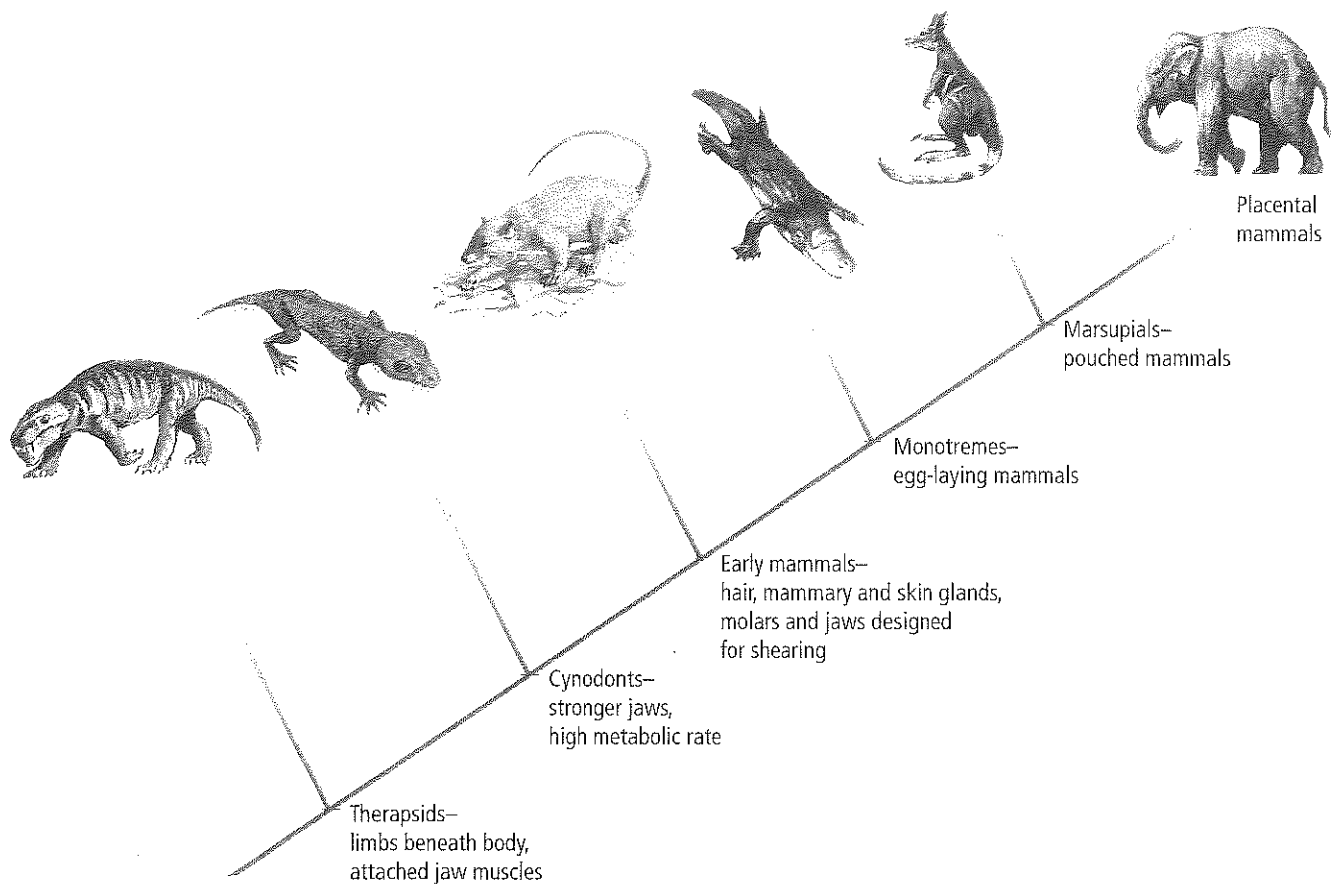
Biologists examined the duration of whales' calls in three different pods for several years. Examine the graphs to the right.

Think Critically

- Evaluate** the trend in call duration of whales in J, K, and L pods from 1977 to 2003. What might account for this trend?
- Hypothesize** what the researchers were investigating in this study.

*Data obtained from: Foote, A., et al. 2004. Whale-call response to masking boat noise. *Nature* 428: 910.





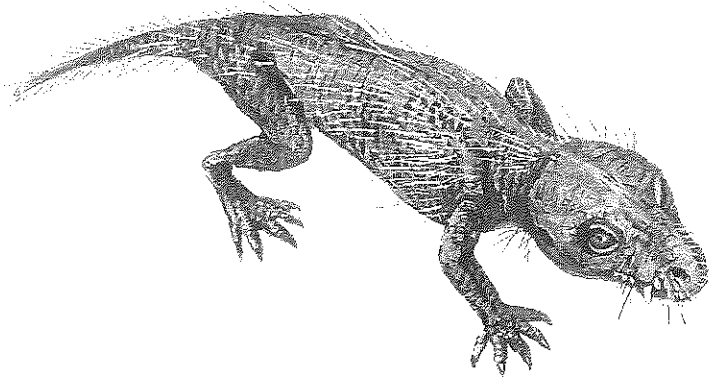
• **Figure 20** Fossil evidence has enabled scientists to make this cladogram that reflects the evolution of living placental mammals. Interpret which present-day mammals are the oldest group?

Evolution of Mammals

The first mammals probably evolved from reptiles in the mid-Triassic period about 220 million years ago. A few lived side by side with the dinosaurs, but mammals did not become common until the dinosaurs disappeared. The cladogram in **Figure 20** shows one interpretation of the evolution of mammals.

Therapsids Fossil evidence indicates that the first mammals probably arose from a group of mammal-like reptiles called therapsids. A **therapsid** is an extinct vertebrate with both mammalian and reptilian features. Therapsids had some characteristics of mammals today, including a pair of holes in the roof of the skull that allowed for the attachment of jaw muscles. Therapsids also had limbs positioned beneath their bodies that allowed for more efficient movement.

Evidence shows that therapsids might have been endotherms. They ate more food than their ancestors, which might have provided them with the energy to produce their own body heat. Being endothermic would have given therapsids an advantage over other ectothermic vertebrates in that they would have been able to be more active during the winter. Therapsids went extinct about 170 million years ago. One subgroup of therapsids called cynodonts continued to evolve more mammalian characteristics, including a high metabolic rate, stronger jaws, and a structure in the mouth that allowed them to breathe while holding food or nursing. A cynodont is shown in **Figure 21**.



Cynodont



Eomaia

Figure 21 Cynodonts were animals that had some characteristics of mammals and were about the size of a weasel. *Eomaia* is the oldest placental mammal fossil discovered.

The Age of Mammals According to fossil evidence, the first placental mammals might have been mouse-sized animals such as *Eomaia*, shown in **Figure 21**. Recently unearthed fossils show some mammals were larger. One was 1m in length with a squat body and predatory teeth. Another had a beaverlike tail adapted to swim. When dinosaurs disappeared at the end of the Mesozoic Era, mammals underwent extraordinary adaptations to the environment. As flowering plants flourished, new sources of nutrition and new habitats became available. Mammals had new environments to fill. For example, fast-moving herbivores and their predators evolved to fill the niches in the drier prairies. The huge expansion in mammalian diversity and numbers led some scientists to call the Cenozoic Era the "Age of Mammals."

Section 2 Assessment

Section Summary

- Of the three subgroups of mammals, only members of one lay eggs.
- Members of one of the mammalian subgroups have pouches in which the young spend most of their development time.
- Placental mammals have young that are nourished by the placenta as they develop in the uterus.
- Mammals might have evolved from reptilian ancestors called therapsids.
- There was a huge expansion in the diversity of mammals in the Cenozoic era.

Understand Main Ideas

1. **MARKING** **Read** Describe the three subgroups of mammals and their features.
2. **Identify** the order or orders to which the following mammal might belong and explain your reasoning: it has reddish-brown fur, two pairs of incisors in the upper jaw (one pair behind the other), claws, a body that is a little smaller than a basketball, and it can jump easily.
3. **Compare and contrast** the characteristics of mammals in order Perissodactyla to those in order Artiodactyla.
4. **Explain** how evidence suggests that mammals evolved from reptiles.

Think Critically

5. **Hypothesize** The bill of a platypus can detect the electrical fields of muscle contraction of other animals. This is how the platypus searches for prey. Form a hypothesis about how this complicated adaptation developed in place of simply searching visually for prey.

WRITING **Biology**

6. Some people have the misconception that marsupials are inferior to placental mammals. Analyze and explain the faulty reasoning of this idea.



In the Field

Career: Comparative Anatomist

Necropsies Help Scientists Study Whales

It is a disturbing sight: A whale beaches itself and, unable to return to the ocean, dies.

Scientists do not fully understand why whales beach themselves, and so they often perform a necropsy, an examination of the body to determine the cause of death. Comparative anatomist Dr. Joy Reidenberg has devoted her career to necropsies of whales and dolphins, a smelly, slimy job that reaps valuable data for scientists.

Whales live so much of their lives in deep ocean waters that scientists have not been able to study them closely. Dr. Reidenberg and other scientists who perform necropsies want to find out how whales died, but they also want to learn more about how they live.

Usually, whales are too large to move and so necropsies are performed where the whales beach. This was the situation in January 2009, when an adult fin whale beached itself and died in a bay off the south coast of Ireland. Dr. Reidenberg and other scientists struggled against rain, hail, and wind to perform a necropsy.

Dr. Reidenberg began by cutting the whale to let out gases caused by decomposition. Once the gases had dispersed, she stripped the blubber off the whale's underside and removed the digestive tract. Dr. Reidenberg found that several chambers of the whale's stomach held nothing but liquid, which meant the whale had not been feeding. Dr. Reidenberg suspected the whale had been sick.

Dr. Reidenberg examined the other organs too. She checked the whale for cuts, bruises, and broken bones, but she found none.



This biologist prepares a whale for a necropsy.

She hypothesized that the sick whale had moved into the shallows of the bay to rest; but when the tide went out, gravity caught up with it. Without water to support it, the whale suffocated under its own weight.

As smelly, slimy, and difficult as it is, whale necropsy is important. If scientists can figure out why whales beach themselves and die, they can work to protect them and other marine animals from conditions that cause premature death. That is not bad for a messy day's work.

WRITING in Biology

News Blog Imagine that you are a journalist for a local newspaper. A dead whale has just washed up on a beach in your town. For your newspaper's Web site, write a blog entry that describes the work of the scientists who perform a necropsy on the beach.

BIOLAB

INTERNET: HOW DO WE IDENTIFY MAMMALS?

Background: The physical characteristics that all mammals share, such as fur and mammary glands, have enabled them to adapt to nearly every ecosystem in the biosphere. Mammals thrive in rain forests, deserts, and polar regions, and they have adapted to the environment near your home or school as well.

Question: *What diversity of mammals can be found in your area?*



Materials

North American mammal identification field guide
binoculars
field journal

Safety Precautions 

Procedure

1. Read and complete the lab safety form.
2. List the mammals you have observed in your area of the country.
3. Predict how these species of mammals would be classified.
4. Design and construct a data table for recording the species; physical characteristics, such as size, body shape, and unique features; and taxonomic classifications of the mammals you have observed.
5. Research the mammals to fill in information in your data table. Either observe the animals in their natural habitat in your local area, such as a park or wetlands, or visit the zoo. If you cannot observe the animals in their natural habitats, obtain information about local mammals from a guide book.
6. Record your observations in your field journal and transfer the information to your data table.
7. Share your results with classmates.

Analyze and Conclude

1. **Describe** basic characteristics shared by all mammals that you have observed.
2. **Compare and contrast** the mammals from your study to those of other students around the country.
3. **Compare and contrast** the physical characteristics scientists could use to separate the mammals into different taxonomic orders.
4. **Infer** how the mammals from your list have adapted to and survived in their environments.
5. **Describe** other observation strategies that could be used to conduct a more comprehensive mammal search of your chosen search area.
6. **Error Analysis** Compare your list of identified mammal species with the lists compiled by other students to determine possible identification errors.

POSTER SESSION

Make a Presentation Collect photographs of the mammals from another area of the country and create a poster to present to your class. Include information about the specific characteristics and adaptations of each mammal.

THEME FOCUS Energy and Matter Mammals' metabolisms need large amounts of energy to sustain their body temperatures.

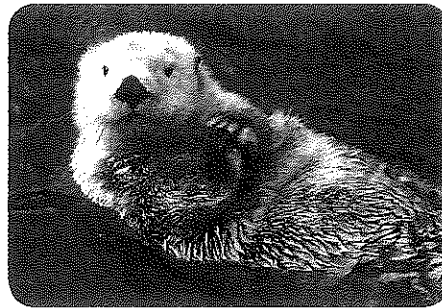
Big Idea Mammals have evolved to have many adaptations for maintaining homeostasis and living in a variety of habitats.

Section 1 Mammalian Characteristics

mammary gland (p. 880)
diaphragm (p. 885)
cerebral cortex (p. 886)
cerebellum (p. 886)
gland (p. 887)
uterus (p. 887)
placenta (p. 887)
gestation (p. 887)

Big Idea Mammals have two distinct characteristics: hair and mammary glands.

- Mammals are successful in a wide variety of habitats.
- Mammals have specialized teeth that are adapted to their diets.
- Respiratory, circulatory, and nervous systems have complex adaptations that enable mammals to have the extra energy they need and to maintain homeostasis.
- Mammals have internal fertilization and, in most mammals, offspring develop within the female uterus.

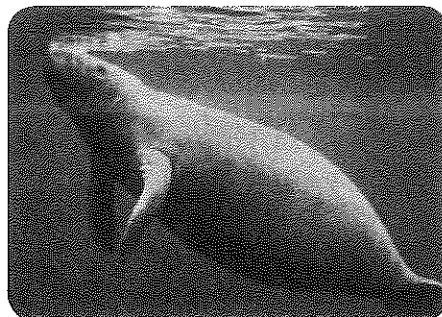


Section 2 Diversity of Mammals

monotreme (p. 889)
marsupial (p. 890)
placental mammal (p. 891)
therapsid (p. 896)

Big Idea Class Mammalia is divided into three subgroups based on reproductive methods.

- Of the three subgroups of mammals, only members of one lay eggs.
- Members of one of the mammalian subgroups have pouches in which the young spend most of their development time.
- Placental mammals have young that are nourished by the placenta as they develop in the uterus.
- Mammals might have evolved from reptilian ancestors called therapsids.
- There was a huge expansion in the diversity of mammals in the Cenozoic era.



Section 1

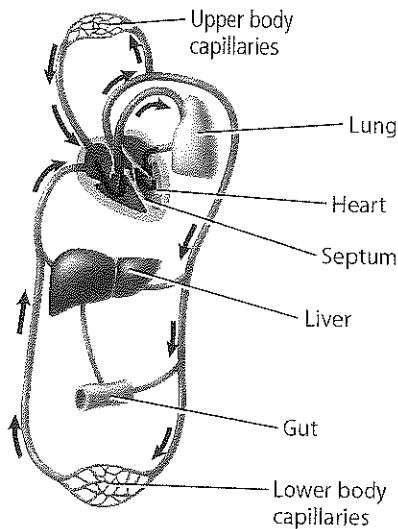
Vocabulary Review

In the analogies that follow, one of the words is missing. Complete each analogy by filling in the blank with a vocabulary term from the Study Guide page.

1. A yolk is to a bird as a _____ is to a mammal.
2. Incubation period is to a bird as a _____ period is to a mammal.
3. The nucleus is to the cell as the _____ is to the brain.

Understand Main Ideas

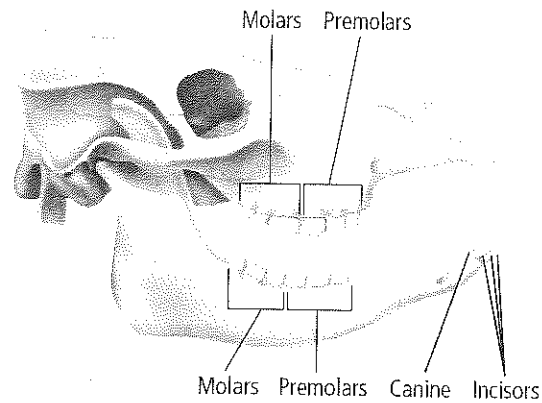
Use the diagram below to answer questions 4 and 5.



4. Which body system is illustrated in the diagram?
 - A. excretory system
 - B. skeletal system
 - C. circulatory system
 - D. reproductive system
5. Which best explains how this system supports endothermy in mammals?
 - A. Oxygenated blood is separated from deoxygenated blood.
 - B. The heart has three chambers and is able to pump more blood.
 - C. This system moves oxygenated blood to the lungs.
 - D. This system moves deoxygenated blood from the heart to the body.

6. Which is the least involved in maintaining homeostasis in mammals?
 - A. kidneys
 - B. heart
 - C. sweat glands
 - D. claws
7. Oil glands, sweat glands, and mammary glands are responsible for which functions?
 - A. hair and skin maintenance, temperature regulation, milk production
 - B. reproduction, hair and skin maintenance, temperature regulation
 - C. temperature regulation, milk production, reproduction
 - D. milk production, oxygen delivery, hair and skin maintenance

Use the diagram below to answer questions 8 and 9.



8. In what way did having a variety of tooth types contribute to the presence of mammals in all habitat types?
 - A. They could eat a variety of foods.
 - B. They could hunt effectively.
 - C. They could digest their food more easily.
 - D. Their digestive tracts were modified.
9. In which trophic category does this mammal belong?
 - A. herbivore
 - B. insectivore
 - C. carnivore
 - D. detritivore

Constructed Response

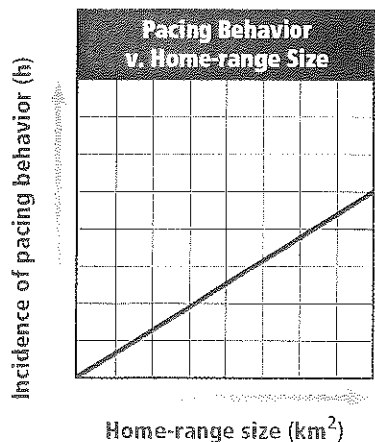
10. **THEME FOCUS Energy and Matter** Examine **Table 1** and form a hypothesis that explains why there are such big differences in the nutrient content of the milk from different mammals.



11. **Table** Refer to **Table 2** which organizes twelve orders of placental mammals. Compare and contrast two of the orders' characteristics.

Think Critically

12. **Design an Experiment** Hippopotamuses secrete a fluid from glands deep in their skin that may function as sweat but can have other functions as well. Biologists hypothesize that this fluid might act as a sunscreen for the skin of the hippopotamus. Design an experiment using beads that absorb ultraviolet light that would test if the fluid on the skin of this mammal provides protection from the Sun.
13. **Analyze and Conclude** Biologists hypothesized that carnivores with large home range sizes, when in captivity in small spaces, had higher incidences of pacing behavior. They studied the arctic fox, the polar bear, and the lion. Analyze the graph below and make conclusions about the effect of confinement on pacing behavior.



Section 2

Vocabulary Review

Each of the following sentences is false. Make the sentence true by replacing the italicized word with a vocabulary term from the Study Guide page.

14. An elephant is an example of a *marsupial*.
15. Mammals might have evolved from *monotremes*.

16. *Therapsids* are egg-laying mammals.
17. *Monotremes* are mammals that have a pouch.

Understand Main Ideas

18. Which mammal is a member of order Cetacea?
 A. beaver
 B. whale
 C. zebra
 D. manatee
19. Which is a benefit of the development of young within a uterus?
 A. Young are born alive.
 B. Predation of the young is less likely.
 C. Predation of the young is more likely.
 D. Young are more fully developed at birth.
20. Which mammal is not a marsupial?
 A. opossum
 B. kangaroo
 C. echidna
 D. wallaby
21. Which is not a characteristic of the duck-billed platypus?
 A. webbed feet
 B. egg-laying ability
 C. three-chambered heart
 D. small, reptilelike chromosomes
22. Examine **Figure 20**. Which mammal evolved first?
 A. elephant
 B. opossum
 C. echidna
 D. blue whale

Constructed Response

23. **Open Ended** Sketch and explain the ideal adaptations of a mammal that lives in 1-m deep marsh water, much underwater vegetation, and predatory snakes.
24. **Table** Suggest an alternative organization of mammal subgroups.
25. **Open Ended** Arrange for a debate in your class about the use of animals for testing medicines and cosmetics.



Think Critically

26. **Infer** Fossil evidence indicates that mammals lived at the same time as dinosaurs for many millions of years. During this time, mammals were very small compared to the dinosaurs. Infer why it might have been an advantage for mammals to remain so small when dinosaurs roamed Earth.
27. **CAREERS IN BIOLOGY** Find out what mammals are endangered in your area. Assume that you will be the zookeeper responsible for providing and maintaining a space for a new animal that is locally endangered and will be kept on exhibit at the zoo. Design a space, feeding routine, and other care instructions for maintaining this animal in your local zoo. Prepare a sign for the space that will alert people of the importance of protecting this endangered species and ways in which individuals can participate in conservation measures.
28. **Research** Select your favorite group of mammals. Make a map that shows its world distribution. Reflect on ecological factors that might currently be limiting its potential range or might affect the group in the future. Make recommendations about what should be done to insure the success of your favorite mammal group.

Use the table below to answer question 29.

Birth Weight and Protein Content of Milk		
Mammal	Days Needed to Double Birth Weight	Protein Content of Milk (g/1000)
Human	180	12
Horse	60	26
Cow	47	33
Pig	18	37
Sheep	10	51
Cat	9	101

29. **Analyze Data** Explain the relationship between the number of days it takes to double birth weight and the protein content of milk. Make a graph of this table.

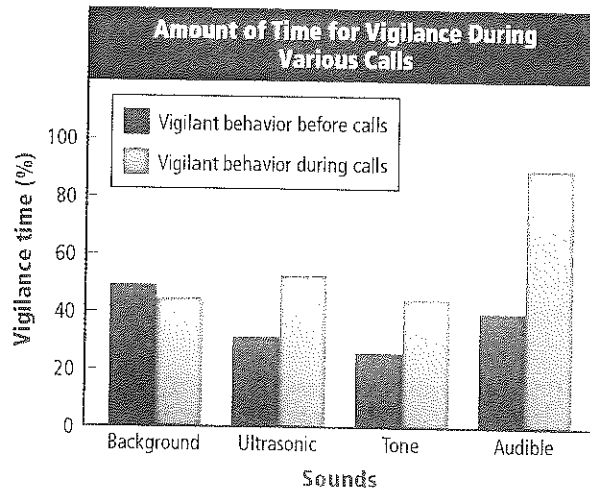
Summative Assessment

30. **Big Idea** Choose a specific mammal and describe several adaptations that help the mammal maintain homeostasis in their habitat.
31. **WRITING IN BIOLOGY** Research which mammal genomes have been sequenced. Write a summary paragraph describing what you learned.

Document-Based Questions

A specific type of ground squirrel was found to have the ability to produce ultrasonic calls that could not be heard by other mammals as well as calls that could be heard (audible). Biologists exposed ground squirrels to the ultrasonic call, background noise, a tone similar to the ultrasonic calls, and an audible call. Then they observed the portion of time the animals spent in vigilant behavior (looking for predators) during each sound. Use this graph to answer the questions below.

Data obtained from: Wilson, D. and Hare, F. 2004. Ground squirrel uses ultrasonic alarms. *Nature* 430: 523.



32. Under which conditions did ground squirrels exhibit the most vigilant behavior overall?
33. Under which conditions might an ultrasonic signal be more effective as a warning?
34. What is the percent difference between vigilant behavior before and after the ultrasonic call?

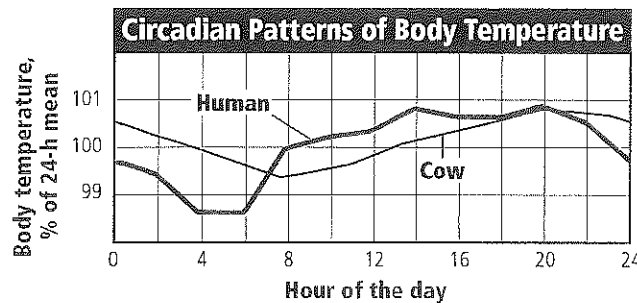
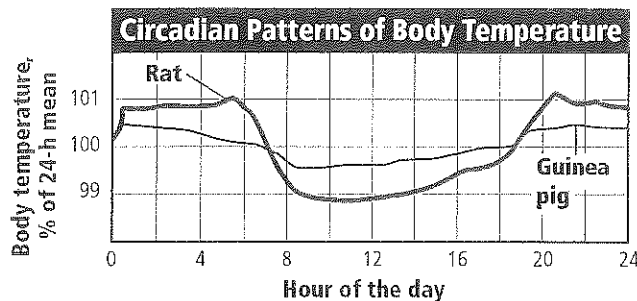


Standardized Test Practice

Cumulative

Multiple Choice

Use the graphs below to answer questions 1 and 2.



- The graphs above show the circadian pattern of body temperature in animals of different sizes. Which animal has the highest mean body temperature?
 - cow
 - guinea pig
 - human
 - rat
- The rat and guinea pig on the graph above are mainly nocturnal animals. What can you infer from this graph about the body temperatures of nocturnal animals?
 - They have higher body temperatures than animals that are active during the day.
 - They have more extreme temperature changes than animals that are active during the day.
 - They have lower body temperatures than animals that are active during the day.
 - They have less extreme temperature changes than animals that are active during the day.

- Which statement describes the difference between invertebrate chordates and the rest of the phylum Chordata?
 - Invertebrate chordates lack a backbone.
 - Invertebrate chordates lack a notochord.
 - Other members of the phylum lack a backbone.
 - Other members of the phylum lack a notochord.

Use the table below to answer question 4.

Row	Group	Some Components of the Digestive System
1	Amphibians	Has gizzard, stomach, intestines
2	Reptiles	Has crop, large and small intestines
3	Birds	Has crop, gizzard, intestines
4	Fishes	Has swim bladder, stomach, intestines

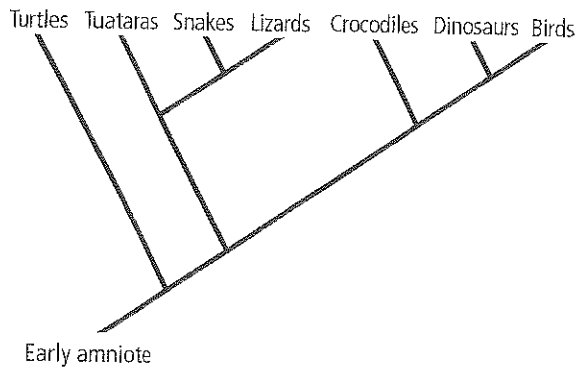
- Which row of information in the table contains correct information about the digestive system?
 - 1
 - 2
 - 3
 - 4
- Pharyngeal pouches are defined as which of the following?
 - cavities that hold food as it is digested
 - sacs that hold the coiled digestive system in place
 - structures that link the mouth cavity and the esophagus
 - structures that regulate metabolism, growth, and development
- How many pairs of jointed appendages do spiders have?
 - 3
 - 4
 - 5
 - 8



Short Answer

- Describe four different characteristics or processes that enable mammals to maintain homeostatic temperature control.
- Compare and contrast the two types of bird feathers.
- Describe two benefits for young mammals receiving milk from their mothers.

Use the diagram below to answer question 10.



- Assess which group of modern reptiles is most closely related to dinosaurs.
- Hypothesize why there are so many different types of birds living today.
- List two ways in which seedless vascular plants are better adapted than nonvascular plants to survive in a changing environment.

Extended Response

- Sea cucumbers protect themselves by casting out their internal organs, but other echinoderms cannot. Hypothesize why this adaptation is found only in sea cucumbers.
- Assess how the skeleton of a bird is adapted for flight.
- Critique why an *r*-strategist population might be better suited to live in an unpredictable climate than a *k*-strategist population.

Essay Question

In most bird species, both parents care for the young. The parents come together during mating season to mate and raise their young. In some bird species, one parent builds the nest and then attracts a mate. In other bird species, the parents build the nest together. The parents often take turns guarding the eggs and keeping them warm. When the young hatch, the parents bring food that is similar to what young birds will eat as adults. This parental care continues until the chicks are ready to fly away. After they leave the nest, young birds are on their own and seldom have any more contact with their parents.

Using the information in the paragraph above, answer the following question in essay format.

- Young birds usually are cared for by both parents. In mammals, the mother often raises the young by herself. Propose a hypothesis that explains why both bird parents care for the young while only the mammalian mother cares for her young. Discuss how the hypothesis could be tested.

NEED EXTRA HELP?

If You Missed Question ...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
30.1	30.1	27.2	29.2	27.2	26.2	30.1	29.2	30.1	29.1	29.2	21.2	27.1	29.2	4.1	29.2

Review Section ...

