I. What is a mammal? (Page 1)

Some mammals that live in Northern climates change color as summer passes into winter. This snowshoe hare is grayish-brown during the summer to blend into the background of its habitat. As winter approaches, the hare grows a new coat of fur that lacks pigment and so is white. Thus, the hare is well camouflaged against the winter background of snow.

A Warning:

In animals that have a potent defense, such as this skunk, color may be used to warn off potential predators. The vivid stripes on this animal’s back serve to identify it as a skunk, a warning usually sufficient to keep people away.

Distract Predators:

Colorful stripes can sometimes camouflage an animal. However, in the case of a zebra herd, the stripes probably serve to distract a predator that has difficulty picking out an individual to attack from a mass of overlapping stripes.

Skin: 

Hairs are produced by the epidermis of the skin. At each site where a hair will form, the epidermis extends deeply into the skin to form a structure called the hair follicle. Cells within the follicle secrete keratin and form the hair which slowly grows up to the skin surface. Glands associated with the follicle secrete an oily substance that coats the hair as it emerges from the follicle. Note also the thin strand of muscle attached to the follicle. In most mammals, contraction of this muscle causes the hair to stand up. In humans, it merely causes “goose bumps.”

Cuticle: 

Observe the scales that cover the surface of these mouse hairs and the human hair, shown at high magnification. The scale pattern of the cuticle differs for each mammal and allows a forensic scientist to differentiate between human and other animal hairs that may be present at a crime scene.

Keratin Structures: 

Other keratin structures found in mammals are also products of the skin epidermis. Claws, nails or hooves, depending on the species, are produced at the ends of digits. Horns are also made of keratin; the rhinoceros horn is actually composed of many coarse hairs fused together.
Thicker Coat:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/thicker_coat.html

This bear pelt is composed of a thick undercoat covered by longer, coarser hairs. The undercoat provides extra...
Almost all mammals have sweat glands to help cool the body. Even dogs, that pant, have a few sweat glands on the bottoms of their feet. Sweat glands are found deep within the skin, but have a duct that leads to the skin surface. Water, as well as some salts, are secreted to the skin surface when the body overheats. As the sweat evaporates, the skin and blood within it are cooled, thus lowering body temperature.

Mammary Glands:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/mammary_glands.html

The mammary glands are similar to sweat glands, but occur in multiples and are much larger. They are designed to secrete milk, a process that begins when the young are born. Hormones present during pregnancy bring the mammary glands to their full development and initiate the secretory process. Mammary glands are located on the ventral side of the body, but vary in number, depending on the species. In humans, a small duct from each gland leads to a nipple, with a tiny space within each duct where milk accumulates. In some mammals, such as cows, sheep and horses, all ducts lead to a large collecting chamber. In these species, a large amount of milk is available when the young suckles and feeding time is short. In species such as humans, the young must suck much longer to obtain the same amount of milk.

I. What is the origin of the mammals? (Page 2)

Synapsid Reptiles:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/synapsid_reptiles.html

Here are two skulls of synapsid reptiles. Note the single opening in the skull just behind the eye socket that identifies these reptiles as synapsids. The upper skull has several different types of teeth, a mammalian characteristic. However, both skulls have other features that are clearly reptilian, as you will learn from the mage farther down on this page.

Early Forms:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/early_forms.html

The upper image depicts an early synapsid reptile called a pelycosaur. It has few mammalian characteristics. Below, we see an artist’s reconstruction of a much more recent synapsid, one of the mammal-like reptiles called therapsids. Observe its stance; the legs are vertically attached to the body as compared to the horizontal attachment seen in the more reptilian synapsid. Also note the mammal-like head of the therapsid.

Herbivores:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/herbivores.html

Here are examples of herbivorous mammal-like reptiles that lived at the same time as the first dinosaurs.

Carnivores:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/carnivores.html

Carnivorous mammal-like reptiles were abundant during the Permian period. The upper carnivore is the more primitive of the two shown here. These animals were probably the top predators of their time.

First Mammals:
These diagrams compare an advanced mammal-like reptile to the first true mammal. The body outlines are based on the fossil skeletons of these animals. The first mammals were small and resembled a modern shrew. They were probably nocturnal, venturing forth at night, when their high body temperature gave them an advantage over the dominant ectothermic reptiles.

**Skull Features of Reptiles vs. Mammals:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_bigimages/skull_features.html

Reptiles have a lower jaw composed of several bones as indicated by colors in the above diagram. The jaw hinge is formed by the small green bone (part of the skull) and the small yellow bone of the jaw. As the synapsid reptiles evolved into mammals, most of the bones comprising the jaw disappeared, leaving a single, jaw bone. At the same time, the green and yellow bones moved into the middle ear cavity. They joined the single bone already present in the middle ear of reptiles to form a group of three bones that transmit sound from the ear drum to the inner ear. Skulls of mammal-like reptiles have features intermediate between those shown above, allowing the evolution of mammals to be traced through several stages of mammal-like reptiles to the first true mammals.

**Three Main Lines:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_popups/three_main_lines.html

Study this phylogenetic chart and note the relationship between egg-laying mammals, marsupials, and true placental mammals. Egg-laying mammals are considered to be the most primitive group of living mammals, whereas the true placental mammals are the most recently evolved and most advanced group.

**II. Which mammals lay eggs? (Page 3)**

**Platypus:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_popups/platypus.html

The platypus is somewhat smaller than a cat. When the first preserved specimen was shown, it was thought to be a hoax—parts of several animals and birds stitched together. The platypus has been likened to an animal designed by a committee”.

**Duck-like:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_popups/duck-like.html

In the front of the platypus head protrudes a broad, flat rostrum that resembles a duck’s bill. It is covered with moist, leathery skin and is used to probe the stream bed in search of food. A pair of nostrils located near the end of the rostrum can close when the animal submerges. The eyes and ear slits are embedded in folds of skin hat cover them when under water.

**Webbed Feet:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_popups/webbed_feet.html

The feet of a platypus are webbed to facilitate swimming. Claws are also present and are used for digging burrows in the stream bank. The male platypus has a sharp spur protruding from the ankle. The spurs are venomous and can be used when fighting with other males or in defense.

**Fur:**
http://courses.ncsu.edu/zo495x/common/zo155_site-wrap/marsupials/marsupial_popups/fur.html

The presence of hair tells us that no matter how odd the platypus may look, it is indeed a mammal. Platypus fur
s soft and luxuriant. At one point in history, the fur was so popular that the platypus was almost hunted to
Aquatic Mammal:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/aquatic_mammal.html

A platypus is rising to the surface in this quiet, Australian stream. Watch how it dives and uses its webbed feet as paddles, when swimming on the surface.

Feeding:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/feeding.html

The platypus is a bottom feeder. Here it can be seen under water, searching the stream bed for food. The front edge of the rostrum contains electroreceptors, much like those of fish. Since the animal’s eyes, ears, and nostrils are closed when underwater, the electroreceptors are used to locate the movement of invertebrate prey.

Echidna:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/echidna.html

The echidna is a round, fat mammal that resembles a porcupine with a long snout. One species of echidna lives in Australia and the other in New Guinea.

Strong Claws:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/strong_claws.html

The long, strong claws of the echidna are used to construct burrows and to dig for food.

Tubular Rostrum:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/tubular_rostrum.html

The long snout of the echidna, called a rostrum, is covered by a tough leathery skin. It is used to probe into the soil where prey may be found. The Australian echidna eats ants and termites, whereas the New Guinea species feeds on worms.

Feeding on Ants:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/feeding_on_ants.html

This echidna is demonstrating the exceptionally long tongue that is housed within the rostrum. The tongue is coated with a sticky mucus, ideal for trapping ants and termites.

Defense:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/defense.html

The echidna’s body is covered with sharp, spiny hairs. When threatened, it curls into a ball with the spines protruding from all sides.

Ankle Spur:
http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/ankle_spur.html

The male echidna, like the platypus, has a spur on its hind legs. However, the echidna spur is not venomous and is smaller than that of the platypus.

Eggs:  http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/eggs.html

As you can see from these photographs, the eggs of egg-laying mammals are quite small. Usually only one or two eggs are laid in a season. After laying, the eggs are incubated on the abdomen of the platypus, while she remains in her burrow, or in a temporary pouch, in the case of the echidna.
As you might expect from the small size of the eggs, the young of egg-laying mammals are very immature at hatching. They are helpless for many days and remain on the mothers abdomen or in the echidna’s pouch, apping up milk secreted by the mammary glands. Note that the mammary glands of these mammals are unique that they lack nipples.

Platypus Young:
http://courses.ncsu.edu/z0495x/common/z0155_site/wrap/marsupials/marsupial_popups/platypus_young.html

This tiny platypus is 3-4 weeks old. It will not grow hair until 7 weeks and its eyes will open at 9 weeks. The baby will suckle for 16 weeks, before it is finally ready for weaning.

Echidna Offspring:
http://courses.ncsu.edu/z0495x/common/z0155_site/wrap/marsupials/marsupial_popups/echidna_offspring.html

The echidna shown here is 12 weeks old. It has tiny spines and its eyes have just opened. The baby can now leave the mother’s temporary pouch and live in her burrow. It requires 20 weeks of development before echidna offspring can be weaned.

V. How do the marsupials differ from other mammals? (Page 4)

Australia:
http://courses.ncsu.edu/z0495x/common/z0155_site/wrap/marsupials/marsupial_popups/australia.html

Marsupials originated in what would become the Americas, before the continents had completely separated. They then migrated throughout the world, as depicted by the white arrows. Marsupials reached the future Australian land mass, shown in pink, by migrating across Antarctica which at that time was relatively warm. Meanwhile, true placental mammals had appeared in Asia and began to migrate as shown by the black arrows. However, before they reached the tip of South America, Antarctica had separated and Australia had become an island. Thus no true placental mammals reached Australia, until brought there by humans, and marsupials evolved without competition. In other parts of the world, the true placental mammals flourished and most marsupials became extinct. The only marsupial remaining in North America is the opossum.

Marsupial Counterparts To Placental Mammals:
http://courses.ncsu.edu/z0495x/common/z0155_site/wrap/marsupials/marsupial_bigimages/counterparts.html

This diagram shows several marsupials in the left column and their true placental mammal counterparts in the right column. Note the similar appearance of the pairs. The diets and lifestyle of these pairs of mammals are also quite similar. Thus the marsupials have diversified along the same lines as the placental mammals when living in similar environments. This is an excellent example of convergent evolution.

Placenta:
http://courses.ncsu.edu/z0495x/common/z0155_site/wrap/marsupials/marsupial_popups/placenta.html

You recently learned about embryonic membranes, when studying the reptilian egg. Mammalian embryos also have a yolk sac, chorion and allantois, but use them for different purposes. In marsupials, the yolk sac (which does not contain yolk) is pressed against the uterus lining to form a “yolk sac” placenta. Nutrients and oxygen from the mother’s bloodstream diffuse into the yolk sac and are carried to the embryo by blood vessels that form a type of umbilical cord. In this photograph, newborn marsupials are still attached to the cords which can
seen emerging from the birth canal. In true placental mammals, the chorion and allantois form the placenta
The newborn marsupials enter a pouch on the mother’s abdomen and attach to a nipple. They complete development within the pouch, nourished by milk. In this photograph, two infant bandicoots have been removed from the pouch. Note that their mouths are still clamped tightly around the nipples.

Kangaroos live on semiarid grasslands, much like antelope and buffalo elsewhere. They are herbivores and have stomachs adapted to digest grass. They are also prolific breeders and will be used to illustrate marsupial reproduction.

The kangaroo embryo remains within the uterus for only 33 days and is extremely immature at birth. It climbs into the pouch under its own power, perhaps using odor as a guide. Once in the pouch the infant kangaroo takes a nipple into its mouth and begins to suckle. The nipple swells, making the attachment permanent for the next 145 days. Thus the mother can hop and run freely without separating the infant from its meal.

In this video, we see a young and somewhat older Joey within the pouch of a wallaby.

Even when beginning to eat grass, a young wallaby will return periodically to the pouch to nurse.

The young wallaby shown here has been weaned, but is still with its mother. It will leave for good when about one year old.

His kangaroo may have mated since the Joey in her pouch was born. If a kangaroo becomes pregnant while an infant is still in the pouch, development of the embryo is arrested. When her young leaves the pouch, the embryo resumes development. After the new baby is born, the first offspring can still return to nurse on its original nipple while the newborn suckles from a different nipple. Thus the kangaroo can have an endless chain of offspring: an arrested embryo in the uterus, an infant in the pouch, and an older Joey returning periodically to nurse.

This is an old video of the last known Tasmanian Wolf which died in the zoo in 1933. It is also called the Tasmanian tiger, probably because of the stripes on its back and hips. Of course, this mammal is neither canine...
nor feline, but a true marsupial. The Tasmanian Wolf id carnivorous and is noted for how wide it can open its jaws which contain an impressive set of teeth.

**South American Marsupial:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/south_america.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/south_america.html)

This rodent-like marsupial lives in Chile.

**Opossum:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/opossum.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/opossum.html)

The opossum is common throughout the United States. It can be found living near humans, if wooded areas are available. City dwellers, seeing an opossum for the first time, often think it is a giant rat.

**Prehensile Tail:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/prehensile_tail.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/prehensile_tail.html)

The opossum's tail is strong and flexible. It is used to hold on to branches as the opossum climbs and can even serve as a hook for hanging upside down in a tree.

**Omnivorous:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/omnivorous.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/omnivorous.html)

One reason for the success of the opossum is its ability to eat a wide range of foods. This opossum is enjoying some ripe persimmons.

**Opossum Young:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/opossum_young.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/opossum_young.html)

Opossum young stay with the mother until they are large enough to forage on their own and protect themselves from predators.

**Playing Possum:**
[http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/playing_possum.html](http://courses.ncsu.edu/zo495x/common/zo155_site/wrap/marsupials/marsupial_popups/playing_possum.html)

When threatened and unable to escape, the opossum can go into a comatose state in which it appears to be dead. The body stiffens, the eyes glaze over, the tongue lolls out of the mouth and the animal drools. This state can last for only 40 minutes or for as long as 4 hours. Since many predators are only interested in living prey, his ploy often saves the animals life. The opossum shown here certainly looks dead, but it is only "playing possum."