FLYING REPTILES

How do vertebrates fly?

**Glide/Parachute**: get high by some other means (climbing, soaring), then toss yourself into the air. Continuously lose altitude, slow rate of descent with membrane.  
**Soar**: use rising atmospheric energy to generate lift  
**Flap**: use body energy to generate lift

Who are the flying vertebrates and how did they do it?

The first flying vertebrates were Gliding Lizards.  
Present in the Paleozoic and Mesozoic.  
Made their gliding/parachuting membranes in a variety of different ways.

*Coelurosaurus*

*Coelurosaurus* was a small lizard-like reptile that lived in western Europe and Madagascar millions of years before dinosaurs appeared.  
It reached a length of about 30 centimeters, at least half of which was made up by a long tail, and had a head adorned with a chameleon-like frill.  
It was one of the victims of a mass extinction that occurred 250 million years ago and since then, no other flying vertebrate has developed wings anything like this animal's.

More than 100 million years before birds made their appearance, *Coelurosaurus* developed its own way to get off the ground.  
*Coelurosaurus* used a unique gliding strategy unlike that of any living animal--and it might have been the best glider the world has ever known.

*Coelurosaurus* flew by gliding.  
It had large retractable wings supported by long bony rods.  
When it wanted to fly, it spread out these elaborate wings and glided.

*Pterosaurs*: were the first abundant and diverse group of flying vertebrates  
They appear in the Triassic, go extinct at end of the Cretaceous.  
Dinosaurs are their nearest relatives.  
They share the advanced ankle structure.
Two major groups of Pterosaurs

A. Rhamphorhynchoids: early pterosaurs
Smaller animals with long tails and little fusion of skeletal bones

*Sordes* a small pterosaur not much larger than a pigeon.
Like all Rhamphorhyncoids the jaws contain teeth; they are small and delicate suggesting a diet of amphibians.
The body appears to be covered with thick, half-centimeter long hair.
The wings, and tail were hair free.
The hair-like covering provided more evidence that Pterosaurs were ectothermic as the hair would have insulated the body and provided a more streamlined profile in flight.
The wing membranes are clearly seen to be attached to the legs, and there is a secondary membrane stretched between the legs.
The tail is not attached to this secondary membrane and is left unimpeded.

*Anurognathus* was one of the last Rhamphorhynchoids, which could be reflected in the absence of a long tail. It was also one of the smallest pterosaurs, having a wingspan of about 30 centimeters.
The skull was relatively small and the jaws contained small stubby teeth.
As compared with other Rhamphorhynchoids which captured prey with their jaws, *Anurognathus* may have used its long legs.

B. Pterodactyloids: later pterosaurs
Could get very large (20 foot wing span), they had small tails, many fused bones in their skeletons, and some had big crests on their heads.

*Pteranodon* is a large pterosaur having a wing span well in excess of six meters.
The head is huge and is adorned with a large crest.
The crest is variable in size and in shape and its function is uncertain.
The jaws are toothless, but fossilized stomach contents reveal a diet comprised of fish.

Fossilized remains of *Pteranodon* have been found in large concentrations in specific localities suggesting a colonial way of life.
*Pteranodon* remains have also been found in marine sediments that are known to be located hundreds of kilometers from shore. This could suggest: after death transportation, but it is much more likely that *Pteranodon* had a large territory and was able to fly great distances in search of food.
How did pterosaurs modify their bodies for flight?

**Bat reconstruction:** wing membranes attach to ankles. Would make the animal extremely awkward when walking on the ground. Would have to generate lift by flapping, or climb onto high things and toss itself off.

**Roadrunner reconstruction:** wing membranes attach to waist. This leaves the legs free for bipedal locomotion. Such an animal could be pretty fast. It could generate lift by running to build up speed, and then just extending its wings. It would rise up like a kite.

Both types of membrane attachments have now been found in the fossil record.

**Pterosaur flight adaptations**

**Wings**

Elongate 4th finger supports the wing membrane, they retain the other fingers in a grasping, clawed hand.

The **pteroid bone** is attached at the base of the wrist, on the front of the wing and faces towards the body. The pteroid bone is the location for the attachment of a thick ligament which ran from the wing to the neck. This ligament served several functions: it allowed for control over the wing, and it enable the folding of the wing against the body.

Fossils of *Rhamphorhynchus* indicate that there were fibers that ran from the leading edge to the trailing edge of the wing. The composition of the fibers are unknown and may have been made of cartilage or keratin. Evidence of these fibers are not always preserved or may not have been present in all Pterosaurs.

**Bones**

Thin, hollow, air-filled bones. Some undergo fusion and loss of bones. Fusion the animal stronger for landing impacts and for generating energy by flapping. Keelend breast bone; expanded plate for flapping muscle attachment. Altered shoulder girdle so that a tendon attached to breast muscles attaches to the back of the arm; allows the animal to pull the wing back by contracting muscles on its chest. Some had crests on their head to aid steering.
**High metabolic rate**

Need high level of energy production to sustain locomotion by flying. Some pterosaurs have been found that are covered with fibers (hair? down?).

**Other features of pterosaur paleobiology**

**Brain size** larger than typical a reptile, but smaller than a mammal or bird. Perhaps the most impressive feature of pterosaurs and certainly the most striking is their large skull. The skull often encompasses greater than 50% of the total body length. It is through detailed examination of Pterosaur skulls that conclusions can be drawn with regards to their intelligence, social behavior, senses, and ecological niche.

While the skull is extremely large for a flying animal it is exceedingly light. The bones of the skull are extremely thin; often no more than a few millimeters thick. In addition to the normal openings for nostrils and eyes there is a third opening located between the two other openings. The purpose of this third opening is not quite certain, but it is probable that it played a role in reducing the weight of the skull.

**Laid eggs?**

Although no verifiable pterosaur eggs have been found, it is strongly presumed that they were oviparous, just like living archosaurs, birds and crocodiles. Pterosaur nests have not been recovered either, but there is dramatic evidence that at least some species exhibited parental care similar to birds and lived in colonies. A jumble of pterosaur bones from the Atacama desert in Chile yielded a large number of juvenile individuals. This would indicate that, like birds, pterosaurs had a prolonged nesting stage while their parents cared for them until they were grown enough to fly on their own.

**Parental care.**

Wear on baby's teeth suggest parental feeding in the nest.

**Feeding**

Just like their modern-day successors, the birds, pterosaurs must have exhibited a wide range of dietary preferences. Paleontologists draw inferences from the shape of the jaws and teeth.
Many species recovered from marine and shoreline deposits had long, pointed beaks and must have been piscivores (fish eaters). Some smaller species had heavy upper jaws and simple peg-like teeth; they may have been insectivores. One unusual pterosaur, *Pterodaustro* from South America, had very long, thin, closely-spaced teeth that must have functioned similarly to the straining filters of today's plankton-feeding flamingoes.

**Birds: dominant modern group of flying vertebrates. Jurassic to Recent**

*Archaeopteryx lithographica*:

The first bird; discovered in 1861; Solenhofen, Germany: late Jurassic lagoonal limestone.

This was a time of great intellectual furor over the idea of evolution. The animal was clearly a reptile, resembling a theropod dinosaur, but with feathers Thomas Huxley studied it and proposed that dinosaurs evolved into birds. The fossil provides strong confirmation of evolutionary transformation.

**What did it look like?**

- Long bony tail, long neck, long legs, short body
- Long arms with three bony fingers and sharp claws
- Long slender jaw with sharp teeth
- Little bone fusion, simple breast bone, hollow bones
- Modified collar bones into a "Wishbone"
- Feathers, that show clear adaptations for flight

**Evidence for relationship to theropod dinosaurs**

Teeth placed well in front of the eyes
On the foot: toe 1 is not attached to the ankle
Hollow bones are present in all theropods
Wishbone, long arms, large hand, three fingers: present in some theropods.
On pelvis: a nobby "boot" is shared with nearly all theropods, a backward pointing boot is present in some theropods.
Many small theropods had feathers (warmth?, display?)

**Shared novelities for birds**

Opposable big toe (for holding onto branches?)
Later Mesozoic birds were better modified for flight

Shortened tail (pygostyle). Fused hand bones to support feathers. Alula: feather extended along front of wing from finger bone to prevent turbulence over wing and maintain lift. Modified shoulder to allow flapping both up and back with contracting of chest muscles (similar to novelty invented by pterosaurs). Deep keel on breast bone. For chest muscle attachment.

Mesozoic birds still retained some primitive traits, however.

Nearly all of them had teeth. Hardly any can be closely related to modern bird groups.

There seems to have been a major expansion of "modern" birds after the Cretaceous-Tertiary extinction.