Adaptation of Birds

Dr.B.Vaseeharan

Department of Animal Health and Management

Alagappa University

Adaptations of birds

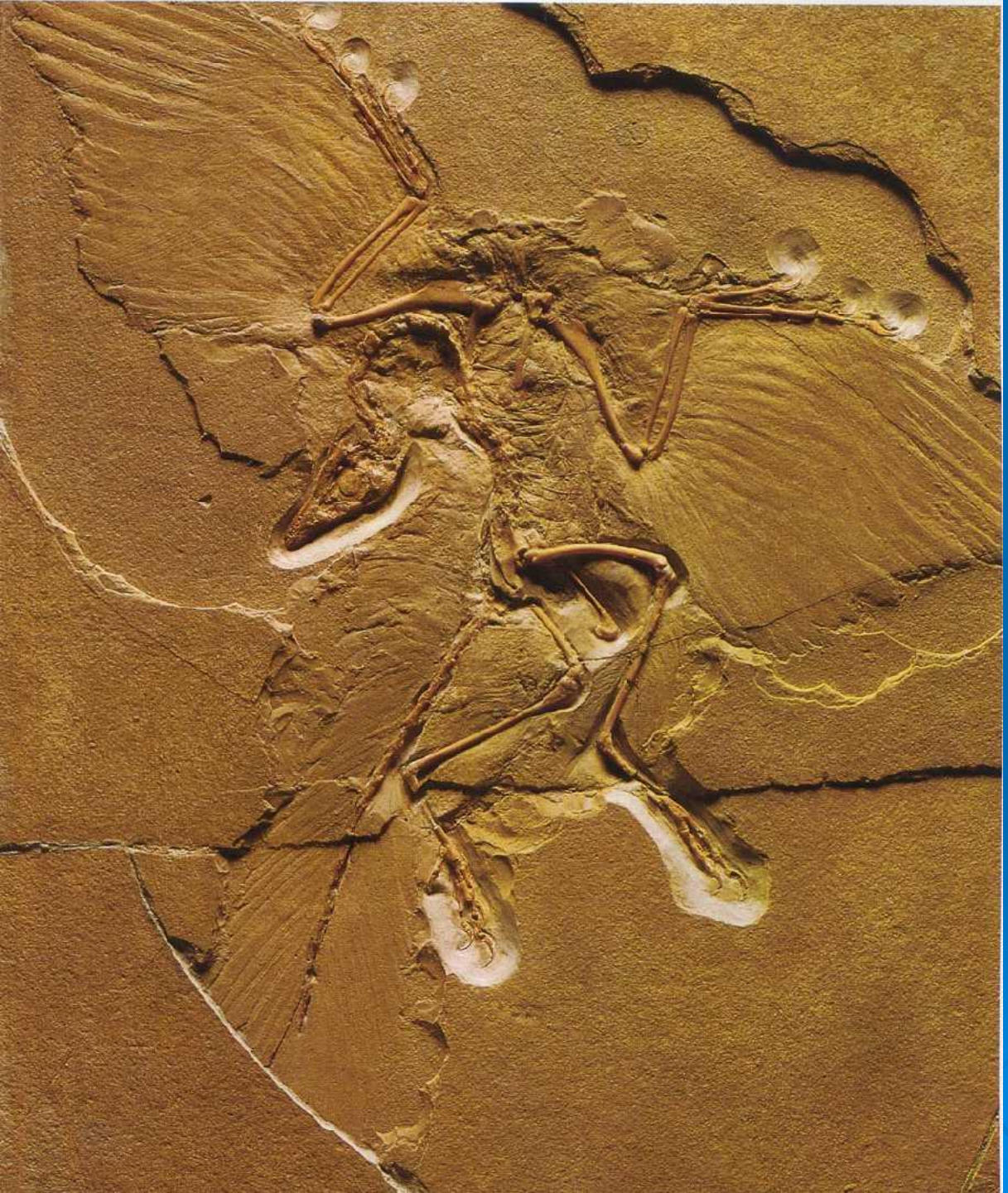
- Feathers a unique character among living animals, but also found in dinosaurs.
- Endothermic
- Skeleton modified for flight. Bones hollow, forelimbs support the wing, ribs with uncinate processes, beak but no teeth, reduced tail.
- Breathing by lungs and associated air sacs
- Internal fertilization and hard-shelled amniotic egg

Evolution of birds

- Birds evolved from a group of theropod dinosaurs in the Jurassic period. The oldest known bird fossil is *Archaeopteryx lithographica* which has a mix of “reptilian” and avian features.

- Reptilian: long tail, teeth, long clawed fingers

- Avian: feathers, ribs with uncinate processes, avian shoulder girdle.



Archaeopteryx (oldest known fossil bird) Jurassic 150mya

Feathers

- Among living animals feathers are a uniquely avian trait.

- However, it is now well established that feathers also occurred in dinosaurs. In the 1990's feathers were described from series of non-avian coelurosaurs, mostly from the Chinese Liaoning deposits.

Feathers

- Feathers are what enable birds to fly, but originally are believed to have evolved as a thermoregulatory device.

- Feathers are lightweight, but strong. The surface of the feather is made up of tightly spaced, overlapping filaments that hook together. Overlapping feathers form the wings with which birds fly.

Dinosaur feather impressions

Feather structure

- Feathers are made of keratin: an inert substance that consists of insoluble microscopic filaments embedded in a protein matrix.

- Keratin is the substance found in hair, nails, claws and scales of other animals, but bird keratin is unique and differs from that of modern reptiles.

Feathers

- There are two main categories of feathers
  - Plumaceous – downy for insulation
  - Pennaceous – linked , vaned feathers wing and contour feathers.

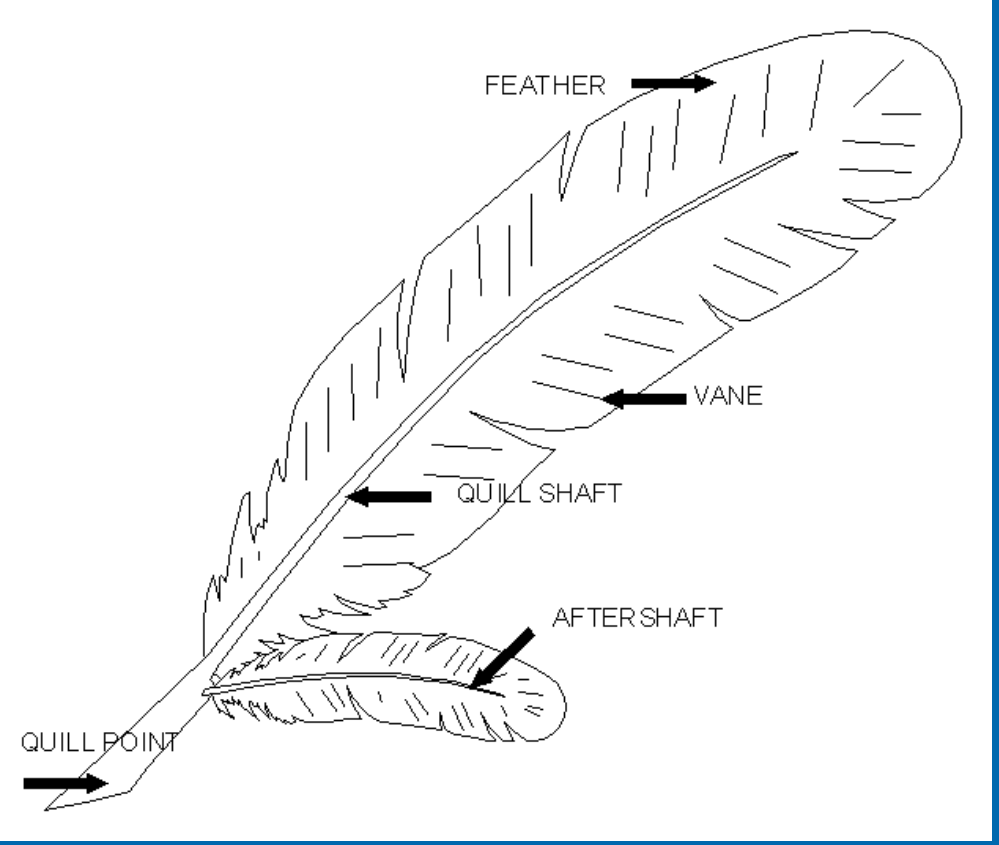
- Vane of a typical body feather consists of a hidden downy base (for insulation) and an exposed cohesive outer portion (for streamlining).

Downy Feather
http://farm1.static.flickr.com/21/33309716_ad54e344dd.jpg?v=0

Feathers

- Body feathers of most birds include an aftershaft that emerges from the underside of the shaft where the first basal barbs of the vane branch off.

- The aftershaft is almost always downy and functions to increase insulation. In ptarmigan winter plumage the aftershaft is ¾ as long as the main feather.



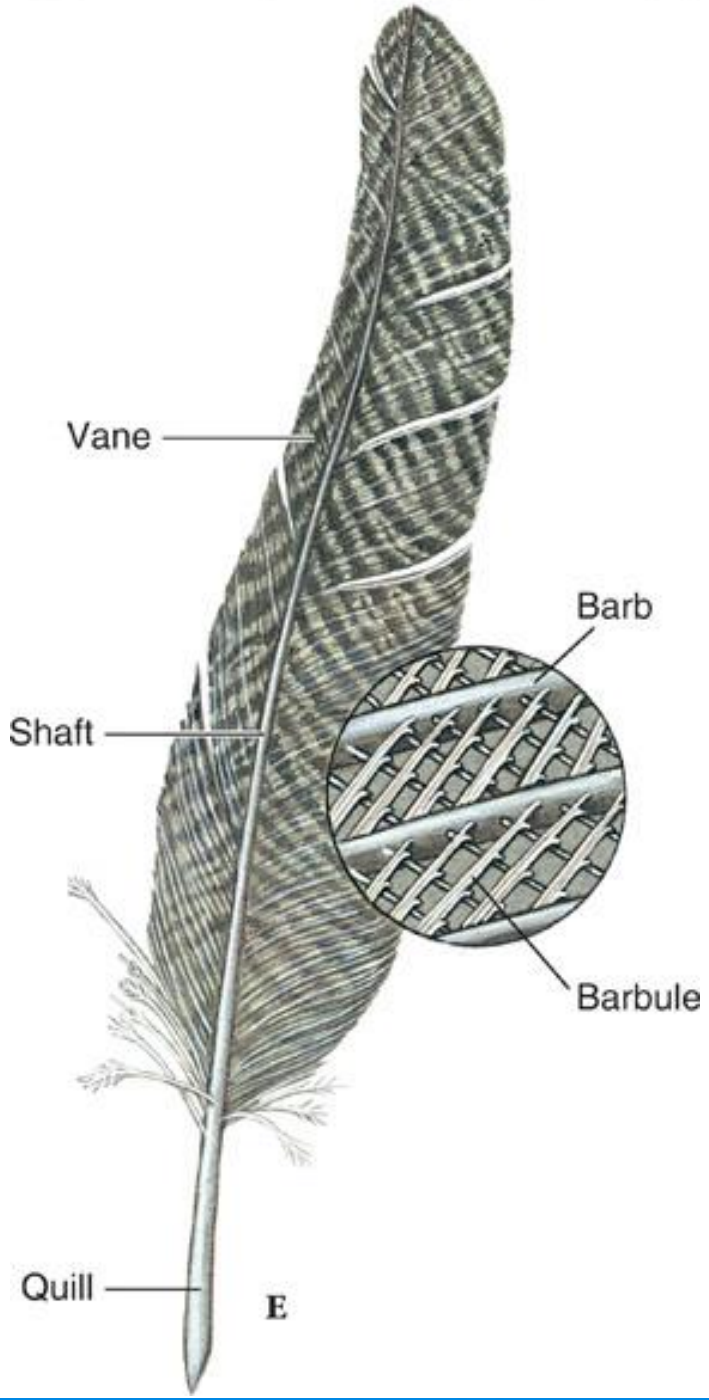
Aftershaft
http://strategis.ic.gc.ca/pics/cp/feather-e.gif

Ptarmigan:
http://fwp.mt.gov/mtoutdoors/images/Portraits/Ptarmigan.jpg

Feather structure

- A contour feather has a long central shaft and a broad flat **vane**. The hollow base of the shaft (**quill**) anchors the feather in a follicle under the surface of the skin.
- The rest of the shaft, the **rachis**, supports the vanes. Branching off from the rachis are **barbs**. Each barb has barbules projecting to either side that interlock with the barbules of adjacent barbs.
- Barbs and barbules form an interlocking, but flexible surface.

Figure 27.05e



Adaptations for flight

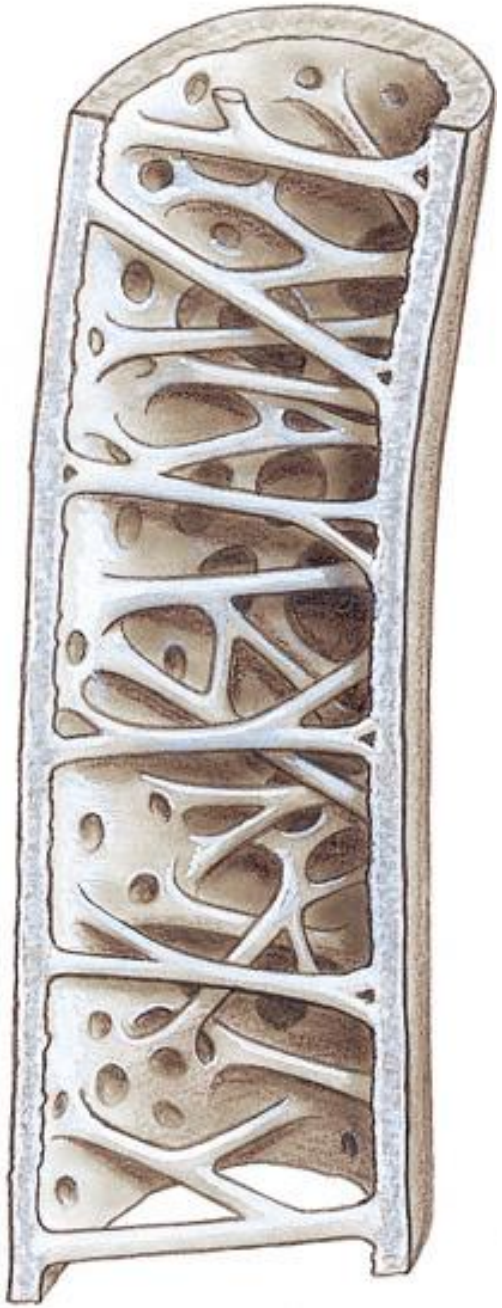
- In general, the avian skeleton has been **lightened** and **strengthened** for flight.

- This has been achieved by eliminating some structures and modifying others.

Adaptations for flight

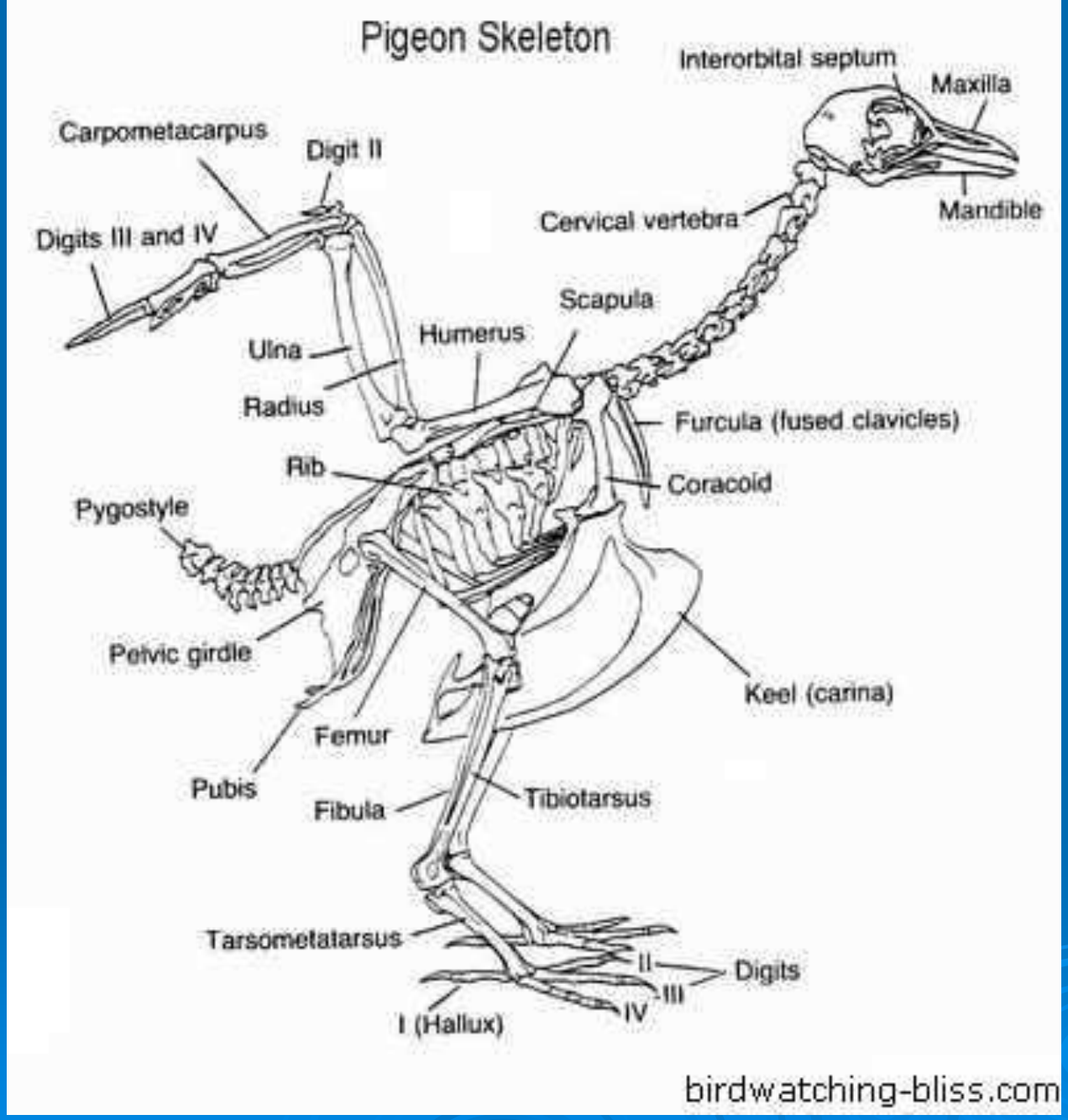
- Feathered wing.
- Mass reduction
  - Wrist bones reduced to two
  - Bones hollow and supported by internal struts or spongy bone
  - Reptilian tail lost. Fused tail bones (pygostyle) support tail feathers
  - Teeth lost. Skull and bill light but strong.

Figure 27.08



Adaptations for flight

- Skeleton strengthened
  - ribs have rear-facing uncinate processes that overlap and strengthen walls of thorax
  - bones of wrist, pelvis fused
- Sternum or breastbone enlarged with a large keel (carina) for attachment of massive flight muscles -- pectoralis and supracoracoideus.
- Fused hand bones support and maneuver primary flight feathers.
- Efficient lungs and powerful four-chambered heart power flight.

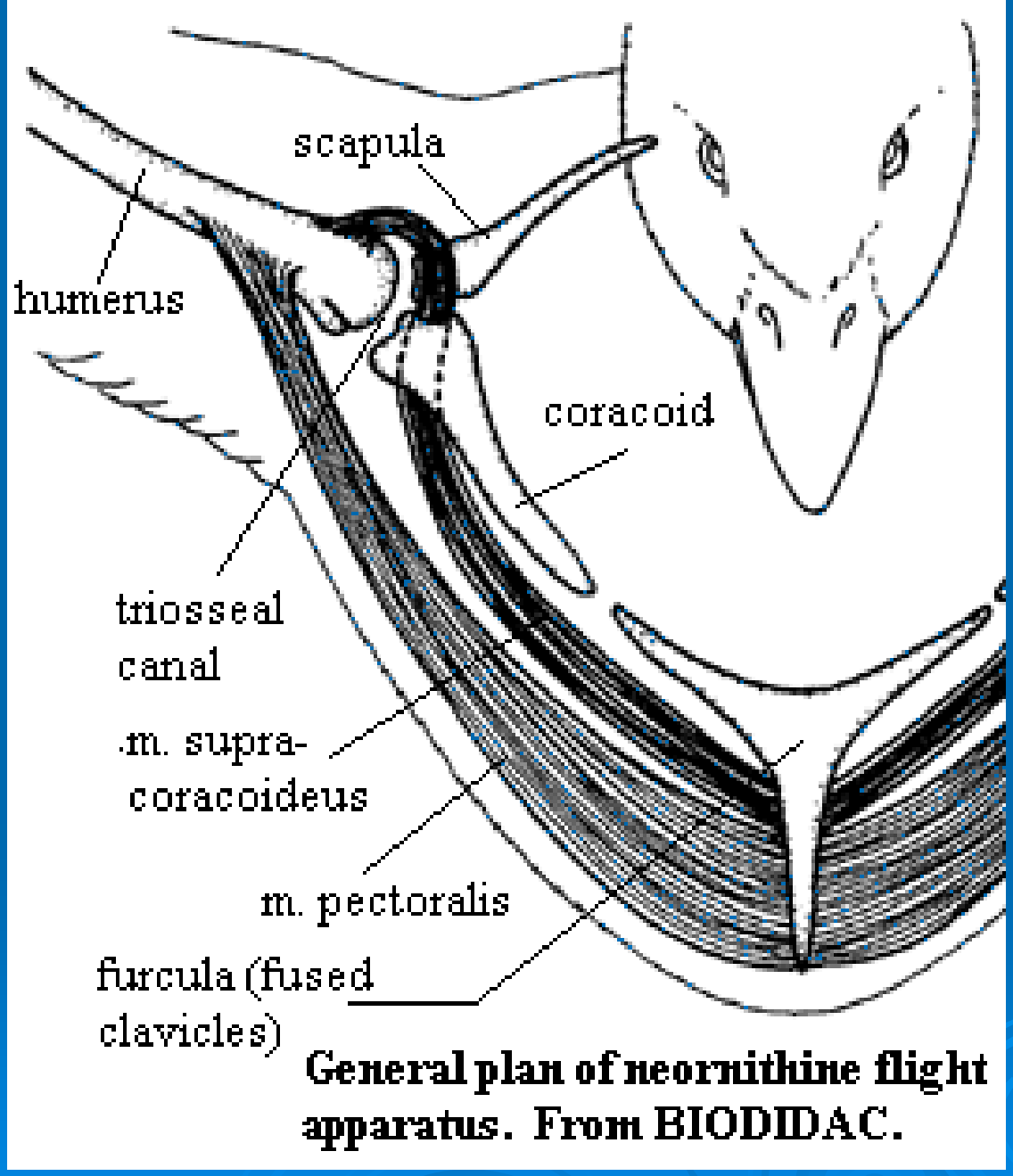


http://www.birdwatching-bliss.com/images/bird_skeleton.jpg

Further skeletal modifications for flight: Triosseal canal

- **Trisosseal canal**. The triosseal canal is formed by the junction of the coracoid, scapula and furcula. The supracoracoideus tendon passes through this canal up from the supracoracoideus and inserts on the dorsal face of the humerus.

- Dorsal insertion allows triosseal canal to act as a pulley and the supracoracoideus can lift the wing during the recovery stroke.



General plan of neornithine flight apparatus. From BIODIDAC.

Triosseal Canal. http://www.palaeos.com/Vertebrates/Units/350Aves/Images/Aves2.gif

Further skeletal modifications for flight: Triosseal canal

- If the supracoracoideus tendon is cut a bird cannot takeoff because the supracoracoideus muscles are required for the initial rapid wingbeats necessary to get a bird off the ground.

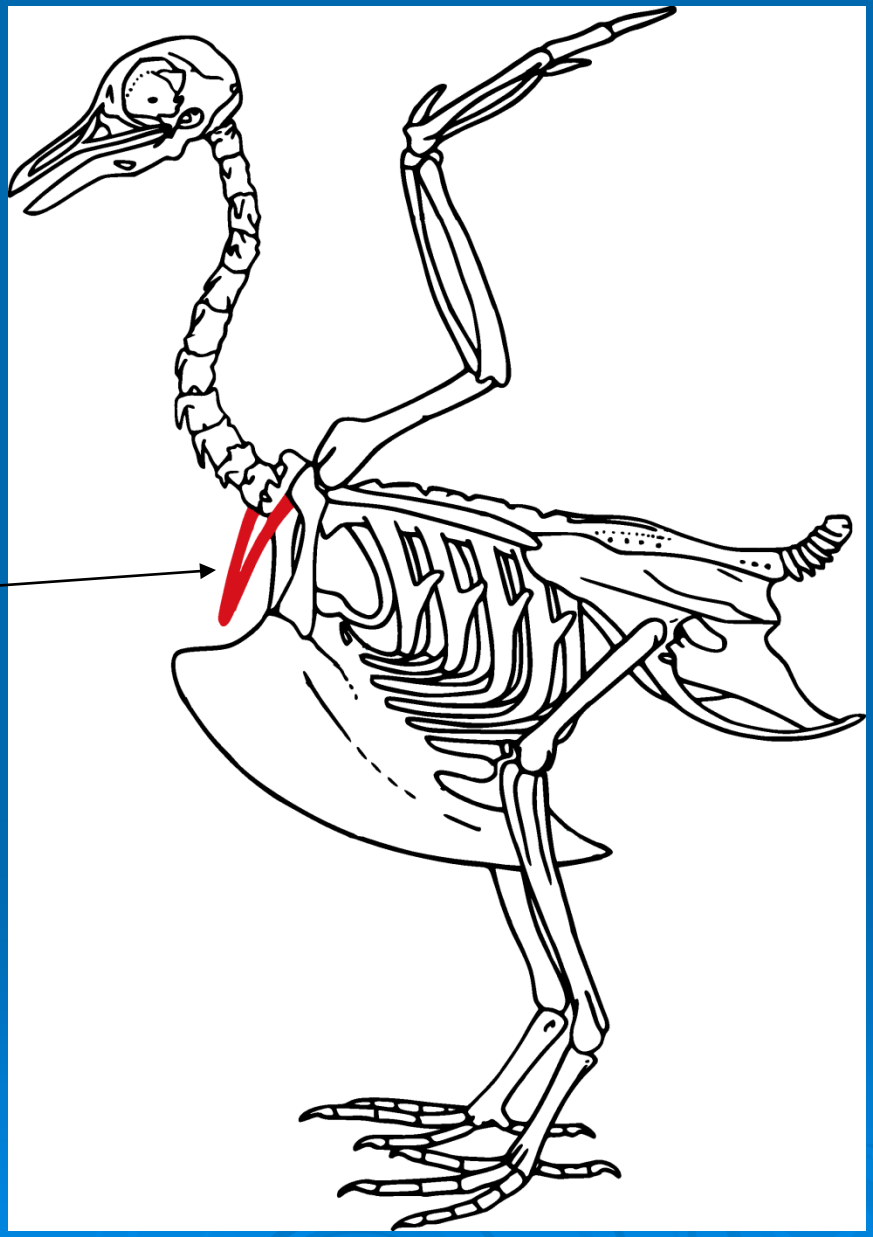
- Once airborne a bird with severed supracoracoideus tendons can fly because the dorsal elevator muscles are capable of raising the wing on the recovery stroke.

Further skeletal modifications for flight

- **Furcula** The clavicles are fused to form a structure called the furcula or wishbone.

- The furcula flexs during flight and spreads and contracts during each wingbeat. The flexing may enhance gas exchange by assisting in moving air through the air sacs.

Furcula (in red)



http://upload.wikimedia.org/wikipedia/commons/6/6e/Furcula.png

Further skeletal modifications for flight: arm and fingers

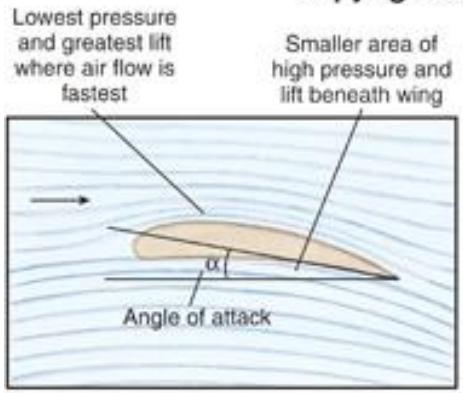
- The wing is supported by the **arm and finger bones**. There are three remaining fingers. The fused hand and finger bones provide strength and rigidity in the outer wing skeleton.
- The primary feathers attach to the wrist and finger bones, while the secondaries attach to the radius and ulna. The first digit (the thumb if birds had one) controls the alula or bastard wing.
- The alula is a flap that is important in maintaining a smooth flow of air over the wing at low speeds (it helps prevent stalling).

http://www.dkimages.com/discover/previews/1244/95005058.JPG

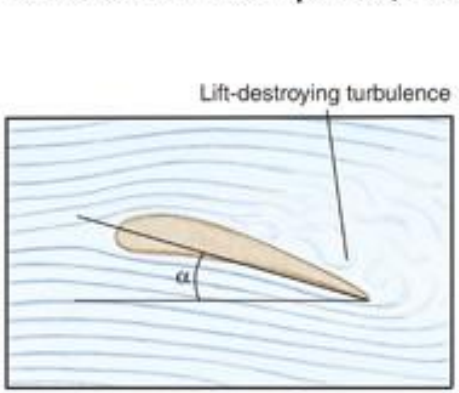
Bernoulli's Principle

- A bird's wing is an airfoil and is cambered with a slightly convex upper surface and concave under surface.
- Because air must travel further over the upper surface of the wing than below it must travel faster and thus exerts less pressure above the wing than it does below.
- The increased pressure below generates lift, the force which keeps the bird up.

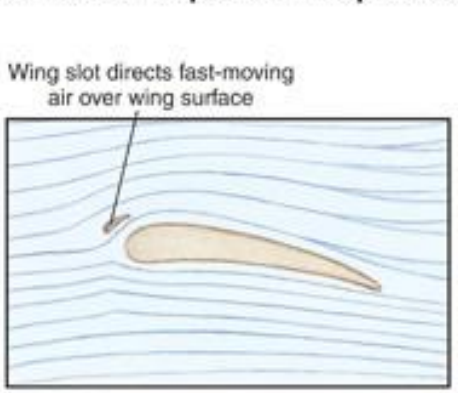
Figure 27.16



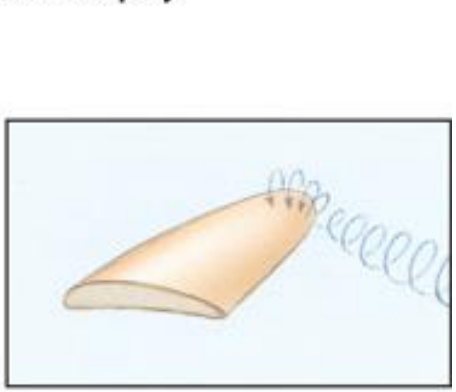
Air flow around wing



Stalling at low speed



Preventing stall with wing slots

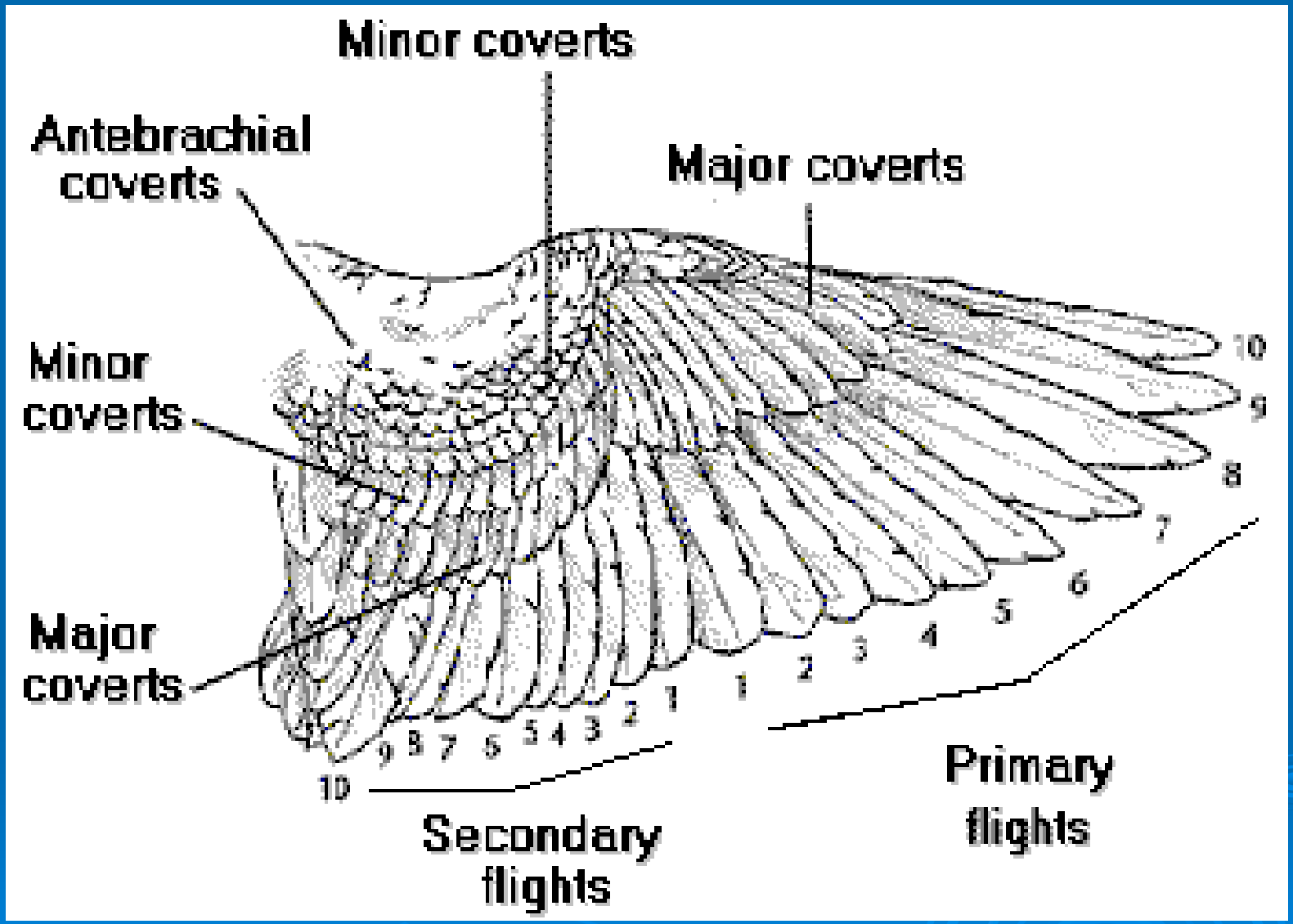


Formation of wing tip vortex

Lift and thrust

- In order to fly both horizontal thrust and vertical lift are required.
- Thrust is mainly generated by the primary feathers (the long ones at the end of the bird's hand), which on the downstroke twist and acting like a propeller push the air backwards.
- Lift is mainly generated by the secondary feathers (the inner portion of the wing), which form an airfoil.

http://www.dkimages.com/discover/previews/981/50392155.JPG

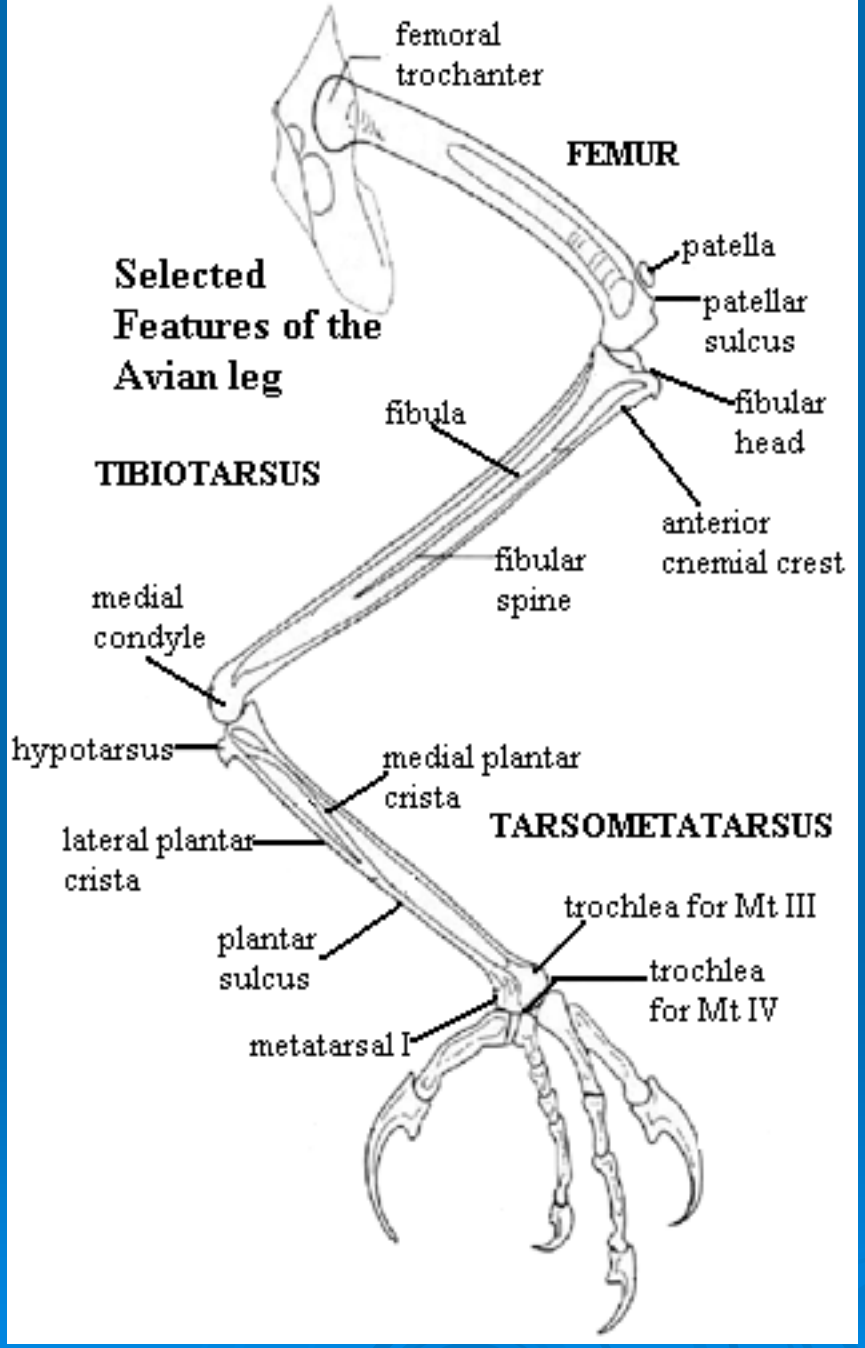


Arrangement of feathers
http://www.birdsnways.com/wisdom/imgs/wingsm.gif

Structure of hindlimbs

- **Legs joints and bones**. When looking at a birds leg what appears to be the knee is not. It is the ankle.

- The knee joint is hidden by feathers. The long bone leading from the toes is the tarsometatarsus (from tarsals and metatarsals) and above that is the tibiotarsus



http://www.palaeos.com/Vertebrates/Lists/Glossary/Images/Hypotarsus.gif

Perching

- Being able to perch in trees was an early avian adaptation.
- The largest group of birds the Passerines (Passeriformes: perching birds) have four moderately long toes, three facing forward and one back.
- The tendons of the toes can lock the foot in a firm grip. Hence a sleeping bird does not fall off its perch.

Perching Song Thrush
http://www.bbc.co.uk/cumbria/content/images/2008/02/13/bird_blue_sky_353x470_334x470.jpg

Hopping and walking

- Most passerines hop and in fact most cannot walk. However, some species that spend a lot of time on the ground such as larks and starlings can walk.

- In many other groups of ground-dwelling birds (e.g. chickens and their relatives) however walking is used.

Running

- A few birds are specialized for running and possess long legs.

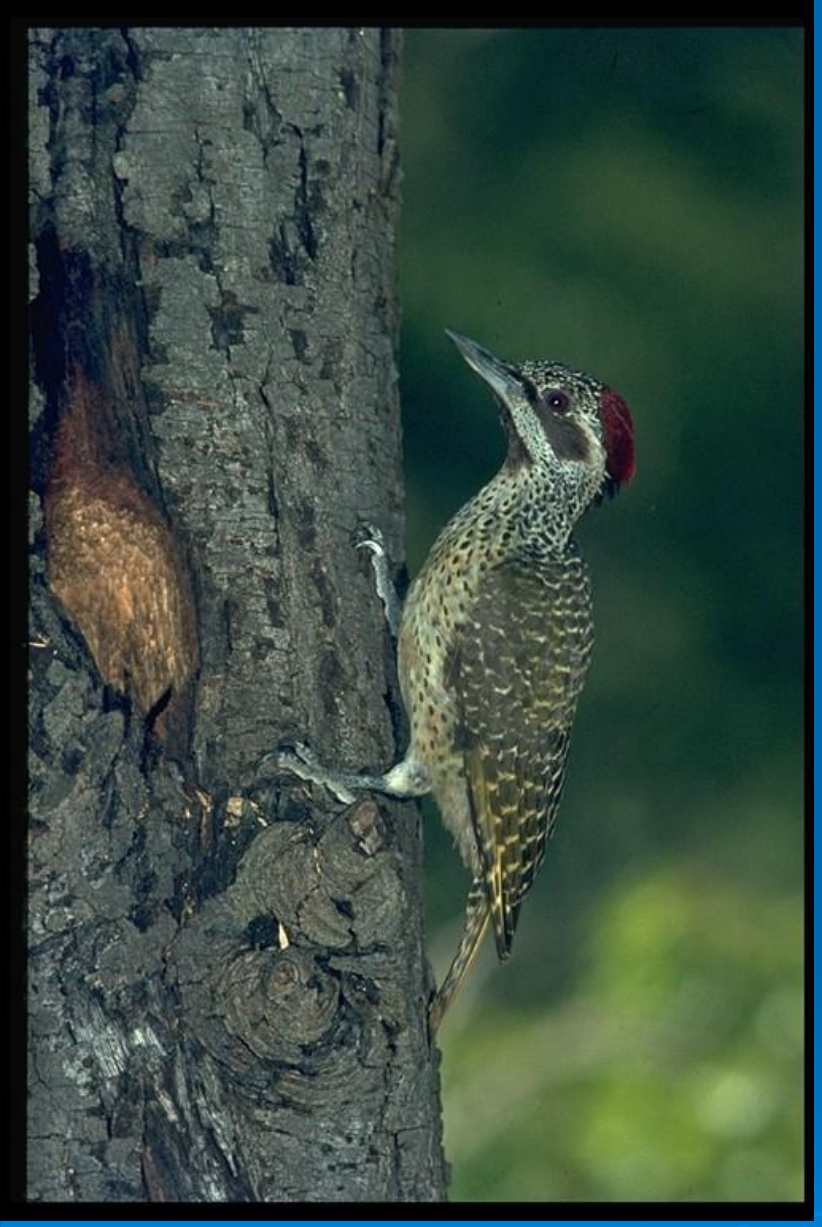
- The most obvious are the ostrich and relatives. As is the case in horses the number of toes has been reduced to reduce mass at the end of the limb. Ostriches have two toes and rheas three.

Ostrich foot: http://lh5.ggpht.com/_jfN-xAu1BR4/Rso0OBjqMjI/AAAAAAAAAS0/jS4eZws8GkY/Zoo+Trip+019.jpg

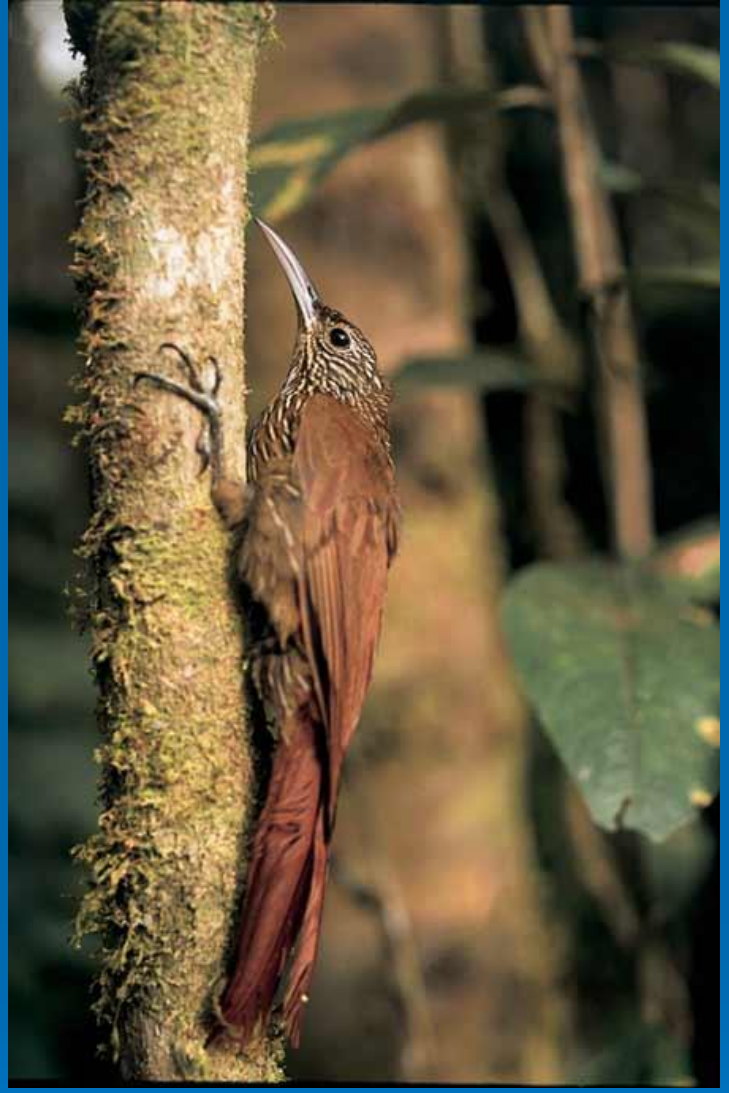
Climbing

- Various birds including woodpeckers, nuthatches, treecreepers and woodcreepers climb up and down tree trunks.

- The feet in all cases are strong and the toes usually well curved and the tail is often used as a brace to prop the body against the trunk.



Bennett's Woodpecker
http://www.exzooberance.com/virtual%20zoo/they%20fly/woodpecker/
Bennetts%20Woodpecker%20268072.jpg



Montane Woodcreeper
http://www.birdsinperu.com/images/
fotos%20aves/Montane-Woodcreeper.jpg

Swimming

- A wide variety of birds swim and webbing of the front three toes has evolved independently at least four times and all four toes are connected by webbing in the pelicans and cormorants.

- The other adaptation to increase surface area for swimming is lobed toes.

Pelican Feet
http://farm1.static.flickr.com/179/476653597_bbd825c035.jpg?v=0

Coot Feet
http://jrcompton.com/photos/The_Birds/J/Jan_07/_JR58714-coot-lobed-feet.jpg