Birds

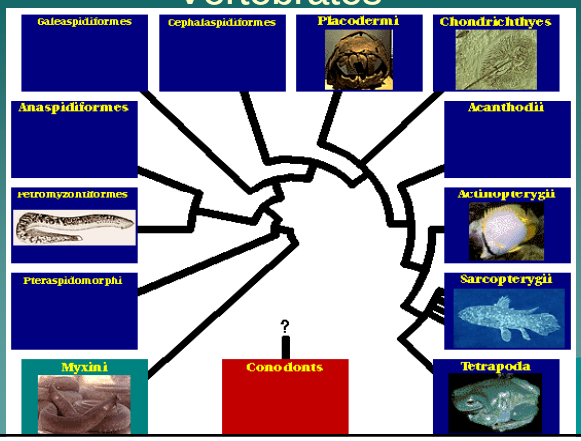
Birds

- Winged bipedal endotermic vertebrates that lay eggs
- Monophyletic lineage, evolved from a common ancestor, and all birds are related through that common origin
- Phylogenetic taxonomy places Aves in the dinosaur clade Theropoda
- 10,000 living species, making them the most numerous tetrapods
- Inhabit ecosystems across the globe
- Birds range in size from 5 cm (hummingbird) to 3 m (ostrich)

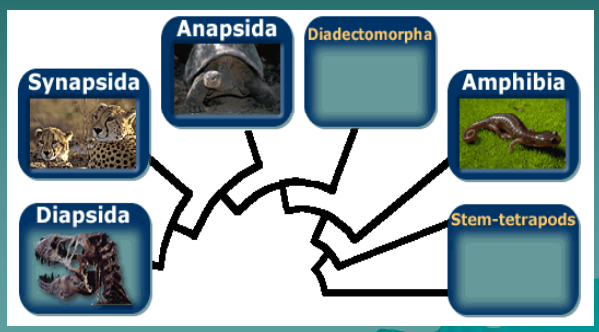
Taxonomy classification of birds Evolutional interests

- birds are not an isolated group of vertebrates
- closely related to dinosaurs, mostly incorporated into them
- belong to the reptile group
- placement of birds in taxonomic system still remains quite unclear
- distant relatives of mammals

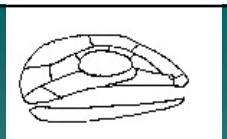
Vertebrates



Tetrapods

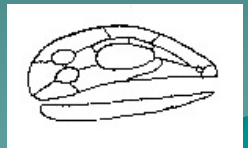


- anapsid skull



- synapsid skull

- diapsid skull



One of the theories of the origin of birds

Diapsida

Archosauromorpha

Lepidosauromorpha
including snakes and lizards

Crocodylomorpha

Dinosauria

many extinct groups, i.e. Tyrannosauria

living species only **Aves**

Other theories classify birds into Archosauria which are paralell to the dinosaur group, and it is claimed, that certain shared traits such as feathers, bipedal movement or endotermie (constant body temperature) originated separately by convergent evolution. For example some dinosaurs may have existed with feathers while lacking a constant body temperature and vice versa

Birds (Aves)

- **endotermic (homoiotherm) evolutional stem of reptiles (diapsid tetrapods)**
  - diapsid skull
    - alveolar dentice
    - antorbital hole
  - active flight ablility
  - endothermic homoiotherm
    - regulation of temperature through an internal physiological mechanism
  - have the highest rate of metabolism and also the quickest movement in the animal kingdom

Traits common to other reptiles

dry skin

one joint connecting skull to spine

intertarsal joint (hindlimb)

urination (kidney structure)

reproduction

Traits similar to mammals

(convergency!)

endotherm
homoiotherm

four chambered heart

internal ear similar to mammals

Characteristics

- feather covered body
- horned beak, no teeth
- complete separation of venous and arterial circulation in the four chambered heart

Highly developed

- specialized care for their young (progeny)
  - large yolked, hard-shelled eggs
- voice, hearing and sight
- sound comunication and complex social behavior
  - due to this many birds species have evolved to a higher intelligence level than most mammals

Skeleton

- Light but strong
- Modified for flight, bipedal locomotion and the laying of large eggs with hard shells
- Bones are very light with large pneumatic cavities which connect to the respiratory system

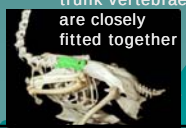
Changes in the skeleton

- pneumatization
  - hollow air filled bones
- Many concretions (thorax, pelvis, limbs)
  - bipedal movement ability and flight
- jaws transformed in beak (bill)

Spine

- number of cervical (neck) vertebra (spondyls) highly variable 11-25
- spine movement is reduced in the anterior thoracic vertebrae
- final thoracic and posterior (lumbar and caudal) vertebra are fused with the pelvis to form the synsacrum
- last few terminal caudal vertebra are fused into pygostyl

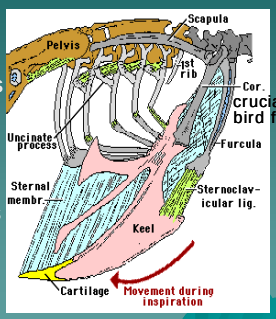
trunk vertebrae are closely fitted together



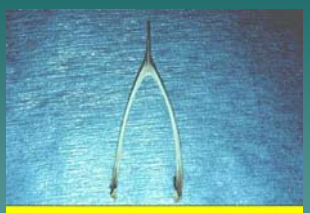
solid synsacrum, to which the pelvis attaches

breast

- 7 to 12 pairs of flattened ribs
- sternum is keeled for the attachment of flight muscles except in flightless bird orders
- sternum immovable
- large coracoid connecting the sternum to the humerus claviculae fused in furcula
- scapulae (shoulder blade) sabre shaped

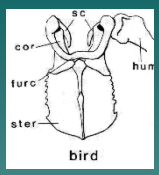


- The furcula, a fused clavicle (collarbone), serves as a brace during the flight stroke



Furculum (Wishbone) = 2 Clavicles

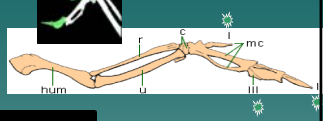
- Crucial for bird flight is a canal formed by the articulation of the **humerus**, the **scapula** and the **coracoid**
- Through this canal, the **foramen triosseum** or **triosseal canal**, operates the tendon of the **supracoracoideus** muscle, which attaches to the sternum and the dorsal side of the humerus, and lifts the wing upwards in flight

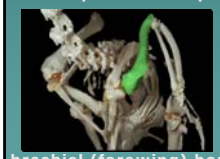


forelimb

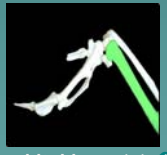
forelimbs modified as wings

- Only 3 digits remain, middle has two phalanges (other two possess only one)
- most of metacarpal and carpal fused in carpometacarpus

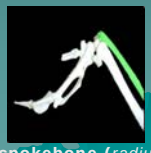




brachial (forewing) bone (*humerus*)

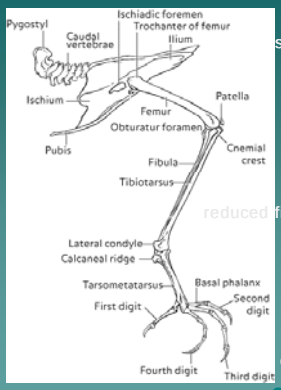


cubital bone (*ulna*)



spokebone (*radius*)

hindlimb



stached femur

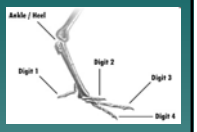
reduced fibula fused with tibia

fused tarsometatarsus

only 4 digits, the first is pointed back

type of bird foot

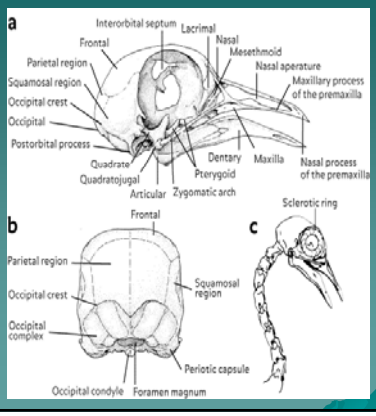
- anizodactyl (most of birds)



- zygodactyl (parrots, cuckos, woodpeckers)

- pamprodactyl (swifts)

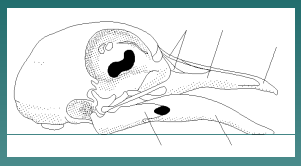
Skull

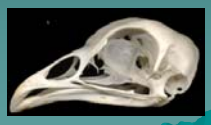


- monocondyl articulation

Skull

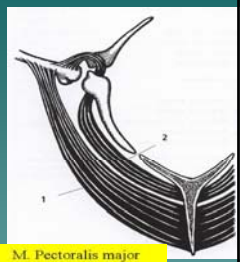
- orbits sheltering the eyes are large and separated by a bony septum
- jaws project forward as a bony beak
- skull bones are fused and do not show cranial sutures



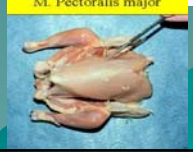


Musculature

- allows for flight
- the powerful downstroke of the wing is powered by the large **pectoralis** muscles, which also attach to the sternal keel
- flight made possible with:
  - large pectoral muscle – movement down - 1
  - supracoracoideus muscle – movement up – 2
- supracoracoideus and the pectorals together make up about 25 – 35% of the bird's full body weight

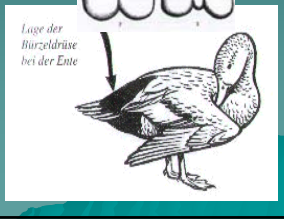


M. Pectoralis major



Body surface

- dry skin without glands
- only one gland - uropygial
- secretion forced into soft feathers

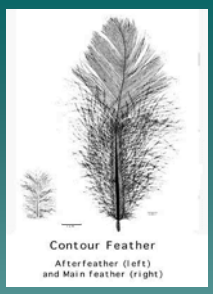


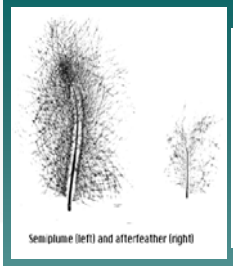
Skin and feather

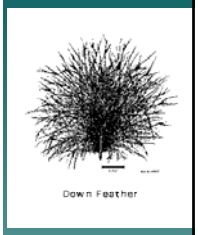
- The one characteristic that distinguishes birds from all other living groups is the covering of feathers
- Feathers are epidermal growths attached to the skin that serve a variety of functions to birds: they aid in thermoregulation by insulating birds from cold weather and water, they are essential to bird flight, and they are also used in display, camouflage and signalling

Feather

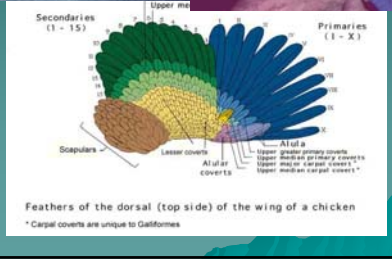
- There are several different types of feather that serve different purposes
- Feathers need maintenance, and birds preen or groom their feathers daily, using their bills to brush away foreign particles, and applying waxy secretions from the uropygial gland







- Caudal feather



Feather

- The arrangement and appearance of feathers on the body is known as plumage
- standard plumage of a bird that has moulted after breeding is known as the 'basic plumage', breeding plumages or variations of the basic plumage are known as 'alternate plumages'

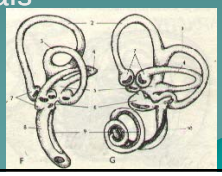
Nervous system

- Large relative to the bird's size
- The most developed part of the brain is the one that controls the flight related function while the cerebellum coordinates movement and the cerebrum controls behaviour patterns, navigation, mating and nest building

- A bird's eyes are developed for taking off, spotting landmarks, hunting and feeding
- The visual system is usually highly developed
- Water birds have special flexible lenses, allowing accommodation for vision in air and water
- Some species also have dual fovea
- The bird retina has a fan shaped blood supply system called the pecten
- Birds with eyes on the sides of their heads have a wide visual field while birds with eyes on the front of their heads like owls have binocular vision and can estimate field depth

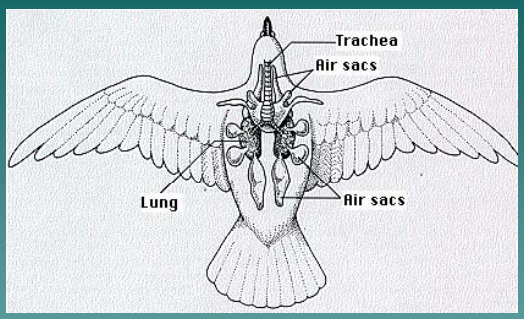
- Birds have three eyelids
- The upper and lower eyelids have small bristle feathers that resemble eyelashes
- Most birds only close their eyelids during sleep, and use the third eyelid alone for blinking
- The third eyelid, the *nictitating membrane*

- Most birds have a poor sense of smell with notable exceptions including kiwis, vultures and the tubenoses
- The avian ear lacks external pinnae but is covered by feathers. The inner ear has a cochlea but it is not spiral as in mammals



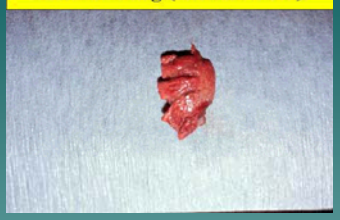
Respiratory system

- highly adapted for flight
- One of the most complex respiratory systems of all animal groups
- When the bird exhales, the used air flows out of the lung and the stored fresh air from the posterior air sac is simultaneously forced into the lungs
- Bird's lungs receive a constant supply of fresh air during both inhalation and exhalation



Lung (Dorsal to Heart)

Excised Lung (Lateral View)



Sound production is achieved using the syrinx, a muscular chamber with several tympanic membranes, situated at the lower end of the trachea where it bifurcates

Syrinx - Bifurcation of Trachea Into Primary Bronchi

Vascular system

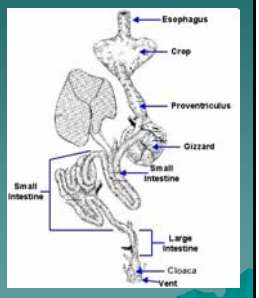
- The bird's heart has four chambers and the right aortic arch gives rise to systemic aorta (unlike in the mammals where the left arch is involved)
- Postcava receives blood from the limbs via the renal portal system
- Birds, unlike mammals, have nucleated erythrocytes, i.e. red blood cells which retain a nucleus
- body temperature 44 °C

Heart Within Pericardium

Excised Heart

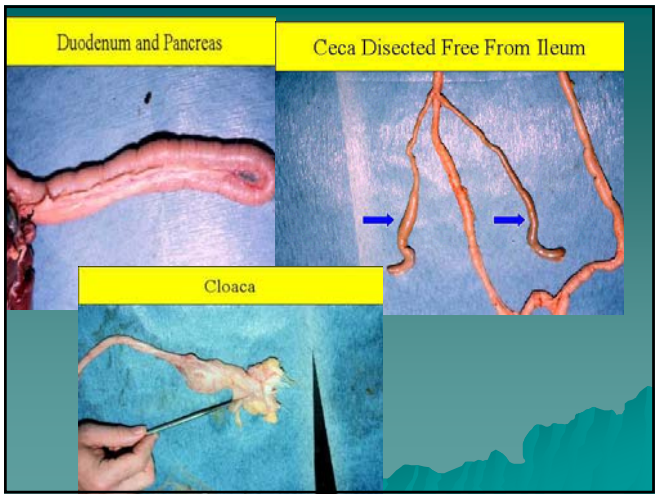
Digestive system

- The mouth cavity roofed with long palatal folds
- Short pharynx
- The stomach comprises a soft anterior proventriculus with thick walls secreting the gastric juices and the diskshaped ventriculus, or gizzard, with dense musculature
- Two blind pouches - caeca
- Cloaca (undigested food, excretory and reproductives organ ending)



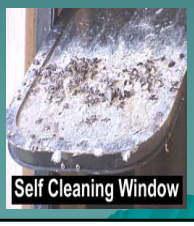
Proventriculus

Trachea (1), Heart (2), Liver (3)



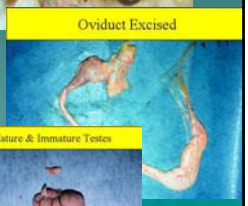
Excretory system

- Kidneys excrete nitrogenous wastes in the form of uric acid, it emerges as a white paste, as well as the output of the intestines, from the bird's cloaca
- The cloaca is a multi-purpose opening: their wastes are expelled through it, they mate by joining cloaca, and females lay eggs out of it



Reproductive system

- female
  - usually only left ovary functions
  - ovum is fertilized in the female bird's oviduct by a sperm cell from the male bird
  - oviduct is a tube that transports the egg from the ovary to the cloaca and where the white of the egg is formed
  - uterus produces a shell
  - In most birds, the ovary releases an ovum at daily intervals during the breeding season until a complete clutch of eggs are laid
  - Once fertilized, the ovum becomes the nucleus of the egg
  - The egg is laid by the female in her nest, incubated, and then the chick is hatched
- male
  - two testes which increase in size (360 fold) during the breeding season to produce sperm



young (chicks)

nidicolous (sightless, featherless, little movable, poikilotherm)

nidifugous

Flight

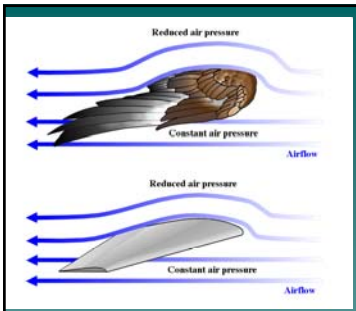
- Characterizes most birds, and distinguishes them from almost all other vertebrates with the exception of mammalian bats and the extinct pterosaurs
- The main means of locomotion for most bird species, flight is used for breeding, feeding, and predator avoidance and escape
- Birds have a variety of adaptations to flight, including a lightweight skeleton, two large flight muscles, the pectoralis (which accounts for 15% of the total mass of the bird) and the supercoracoideus and a modified forelimb (the wing) serving as an aerofoil

Flight

Theories of genesis

- from the trees down
  - birds' ancestors first glided down from trees and then acquired other modifications that enabled true powered flight
- from the ground up
  - birds' ancestors were small, fast predatory dinosaurs in which feathers developed for other reasons and later evolved to provide first lift and then true powered flight
  - birds' wings originated from forelimb modifications that provided downforce, enabling the birds to run up extremely steep slopes such as the trunks of trees
- wing-assisted incline running
- flight evolved by modification from arboreal ambush tactics

- The mechanics of bird flight is designed through varied forms of bird's wings
- The specifics of hovering, take-off and landing are also examined
- Finally, additional adaptations of bird's bodies relating to their flying ability are covered



- aerodynamic body shape
- skeleton
- feathers (body surface)
- pectoral musculature
- poweful respiratory system- lungs with posterior air sacks
- fast metabolismus

Flight

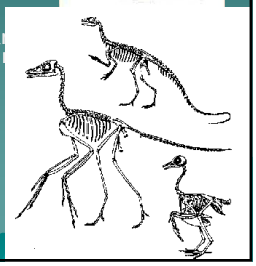
- Wing shape and size primarily determines the type of flight each species is capable of
- Many birds combine powered or flapping flight with less energy intensive soaring flight
- Flight assists birds with feeding, breeding and avoiding predators
- About 40 species of extant birds are flightless, and many extinct birds were also flightless
- Flightlessness often arises in birds on isolated islands, probably due to the lack of land predators and limited resources

Behaviour

- Some birds, especially corvids and parrots, are among the most intelligent animal species; a number of bird species have been observed manufacturing and using tools, and many social species exhibit cultural transmission of knowledge across generations
- Many species of bird undertake long distance annual migrations, and many more perform shorter more irregular journeys
- Birds are social and communicate using visual signals and sounds such as calls and bird song
- Birds are primarily socially monogamous, with engagement in extra-pair copulations being common in some species; other species have polygamous or polyandrous breeding systems
- Eggs are usually laid in a nest and incubated and most birds have an extended period of parental care after hatching

Origin and evolution

- birds evolved from dinosaurs, specifically theropods. Birds are members of Maniraptora, a group of theropods which includes dromaeosaurs and oviraptorids, among others
- importance of discovery of „first bird“ *Archaeopteryx*, from the Kimmeridgian stage of the Late Jurassic (some 155-150 million years ago), which is the earliest known bird under definition but retains many reptilian as well as bird traits
- *Archaeopteryx* continues to play an important part in scientific debates about the origin and evolution of birds
- ability of flight is controversial (flapping or glider)



Achaeopteryx

- jaws with sharp teeth
- three forelimb fingers with claws
- a long bony tail
- hyperextensible second toes ("killing claw")
- feathers (which also suggest homeothermy)
- various skeletal features

number of features common to both birds and dinosaurs, *Archaeopteryx* has often been considered a link between them —possibly the first bird to change its behaviour (from a land dweller to a bird)

Phylogeny

- Phylogenetic taxonomy places Aves in the dinosaur clade Theropoda
- According to the current consensus, Aves and a sister group, the order Crocodilia, are both living members of the reptile clade Archosauria

- Modern birds are classified as Neornithes

The Neornithes are divided into the Paleognathae and Neognathae

Subclass: Paleognathae (paleognaths)

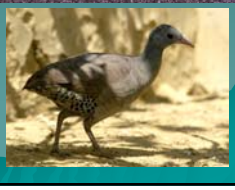
- Paleognathes are named for a characteristic, complex architecture of the bones in the bony palate
  - vomer is large and articulates with premaxillae and maxillopalatines anteriorly
  - posteriorly vomer fuses to the ventral surface of the pterygoid, and palatines fuse to the ventral surface of pterygovomer articulation
  - palatine and pterygoid fuse into a rigid joint
  - pterygoid–quadrate articulation is complex and includes orbital process of the quadrate
- similar pelvis anatomy - large, open ilio–ischiatic fenestra in the pelvis

Subclass: Paleognathae (paleognaths)

- The paleognaths include the tinamous of Central and South America as well as the ratites
- The ratites are large flightless birds, and include ostriches, cassowaries, kiwis and emus, though some scientists suspect that the ratites represent an artificial grouping of birds which have independently lost the ability to fly in a number of unrelated lineages
- male incubates the eggs

Order: Tinamiformes

- Compact body, thin neck, small head with a beak tha curves slightly downward, short wings and tail, and f infrequently
- Thick, medium-length legs with three toes pointing forward and one pointing backward
- Preen gland that secretes an oil they use for grooming



„ratites“

- polyfyletic group
- Simplified wing bone structure
- Powerful long legs and neck
- No feather vanes, making it unnecessary to oil the feathers
- No preen gland that contain preening oil
- flightless
- Coracoid and scapula small

Order: Struthioniformes (ostriches)

- only one current species African Ostrich
- the largest living bird
- only two digits on the foot

Order: Rheiformes (rheas)

- large, flightless birds with gray-brown plumage, long legs and long necks
- native to South America
- wings large for a flightless bird and are spread while running, to act as sails

Order: Casuariformes (cassowaries and emus)

- very large flightless birds native to Australia and New Guinea

Order: Apterygiformes (kiwis)

flightless birds

endangered, endemic to New Zealand

long bill

no keel on the breastbone to anchor wing muscles, and almost no wings

feathers lack barbules

small pygostyl

large eggs (only one is laid per season)

Subclass Neognathae (neognaths)

- differ from Palaeognathae in the structure and connection of their jawsbones (see Pg), suture are not visible
- have fused metacarpals, an elongated third finger, and 13 or fewer vertebrae

Infraclass: Galloanserae (geese, ducks, quails, pheasants)

- The basal , divergence from the remaining Neognathes was that of the Galloanseri, the superorder containing the Anseriformes (ducks, geese and swans), and the Galliformes (the hens, pheasants, grouse, and their allies)

Order: Anseriformes (waterfowl)

- aquatic birds, highly adapted for an aquatic existence at the water surface
- compact bodies with long necks and full webbing between the three forward-pointing toes
- The lower bill is flat while the upper is cone-shaped with a sort of nail at the tip
- Unable to glide but can fly quickly with their necks outstretched
- Web-footed for efficient swimming (although some have subsequently become mainly terrestrial)
- phallus

Order: Galliformes (chicken-like birds)

- Short bills that usually curve downward to assist in pecking plant material from the ground
- Their feet are big and strong—so strong that they can move heavy branches or stone
- Some galliform tails are one-third the size of their total body length
- Both sexes are often brown or black, but the males of a few species are incredibly colorful
- Feathers with aftershaft
- herbivorous or omnivorous

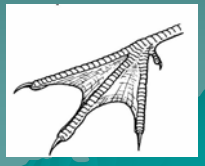
- turkeys
- quails and pheasants
- grouse

Infraclass: Neoaves

- all other birds
- sometimes called higher neognaths

Order: Gaviiformes (loons)

- divers, aquatic birds
- anatomy is specifically geared toward its need to capture fish
- body is torpedo-shaped, and its neck is thick but longer than the average water bird
- heavy bones
- three toes on each of the two webbed feet, and the legs are toward the back of the body
- though the loons' underparts are totally white, the upperparts are dark grey or black, and the wings have a black-and-white checked pattern on them
- all loons have red eyes and long beaks



Order: Podicipediformes (grebes)

- Excellent swimmers and divers
- Wings are rather short and skinny
- Coloration varies, depending on whether or not they are breeding
- Eyes may be yellow, red, or brown, and their bills are short
- Their feet have adapted, changed over time, to swimming, they are unable to walk well on land and can do so only for short distances

Procellariiformes (albatrosses, petrels)

- Seabirds
- Tubular nostrils
  - In the albatross, the nostrils stick out from both sides of the bill.
  - In the other families, the nostrils sit at the base of the upper bill.
- Differ from other birds in that they have a highly developed sense of smell, which helps them locate food and breeding sites
- This sharp hook, which is actually formed by a plate, allows the birds to hold on to slippery foods such as fish and squid
- long Wings
- Contain oil in their stomachs that acts as a food source during long periods between meals

Sphenisciformes (penguins)

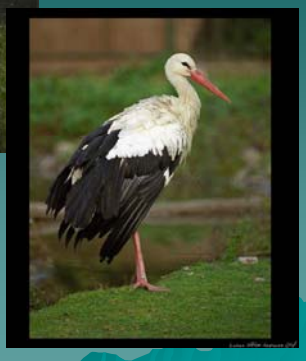
- Large heads and long bodies - resemble humans when they waddle around on their two webbed feet
- Short feathers, which provide excellent insulation against the cold air and water temperatures
- Wings are stiff flippers that help them navigate the ocean waters (paddlelike)
- Cannot fly and their bones are much more solid and heavy than those of most birds. This is an adaptation that allows them to dive for food
- Differ from other birds in that, except for a patch on their bellies, their entire bodies are covered with feathers

Pelecaniformes (pelicans, cormorants)

- Webbing that connects all four toes
- Interesting bills
- Nostrils vestigial
- Most of the other have bills with serrated edges like the blade of a bread knife. These edges help the birds hold slimy fish
- Bills have a hook on the end, the hooks help tear apart the birds' prey,
- Bare skin pouch or throat sac
- The pouches can be fluttered to help cool the birds
- After swimming, the birds have to spread their wings to dry them in the sun

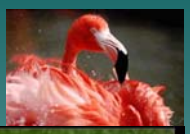
Ciconiiformes (storks, herons, ibises)

- Long necked and long-legged wading birds
- Single pair of sternotracheal muscles in the syrinx
- Little or no web between toes, the middle claw is laterally expanded
- With either decorative plumes
- Food chiefly fish and other aquatic animals



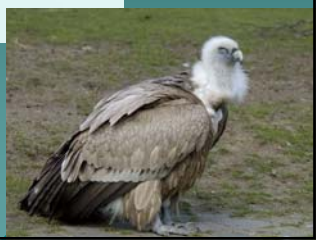
Phoenicopteriformes (flamingos)

- Now often belongs to Ciconiiformes
- Bill abruptly decurved at middle
- Mandibles bent
- forming box with serrated margins
- Sieving plankton from water



Falconiformes (falcons, eagles, hawks)

- Bill stout, beak sharply hooked at tip, with soft naked skin (cere) at base
- Mandibles sharp-edged
- Leg strong, feet usually with talons adapted for grasping, sharp curved claws
- Wings long and fairly broad, suitable for soaring flight
- Predaceous, active by day
- Flight strong, rapid in some
- Monogamous, young have a long, very fast-growing fledgling stage



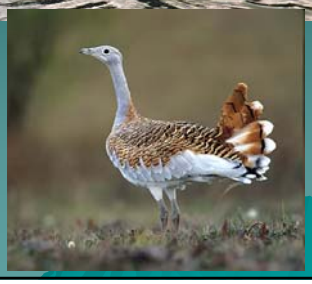
Charadriiformes (gulls, button-quail, plovers)

- Various types (shorebirds, „waders“)
- Toes usually webbed at least at the base
- Plumage dense and firm
- Shorebirds - more or less longlegged
- Gulls - strong winged
- Auks with 3 toes and legs far back on the body
- Often live near water and eat invertebrates or other small animals

Gruiformes (cranes, rails, coots)

- Various types
- Feathers with aftershaft
- either possess large size or strong flight abilities
- inhabit marshes or prairies – open
- crop absent





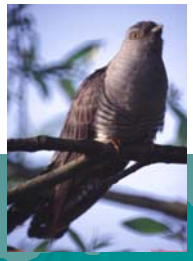
Columbiformes (doves and pigeons)

- Bill usually short and slender, with thick soft skin (cere) at base
- Tarsus usually shorter than toes
- Crop large, producing „pigeon milk“ to feed young

Psittaciformes (parrots)


- Beak stout, narrow, sharp edged and hooked at tip
- Upper mandible highly movable on frontal bone of skull
- Bill with soft cere, often feathered
- Toes 2 in front and 2 rear (outer hind not reversible), zygodactyl, adapted for grasping

Cuculiformes (cuckoos)

- Toes 2 in front and 2 rea (outher hind reversible), not adapted fot grasping
- Tail long
- Bill moderate
- Often egg-parasitic-female laying egg in nest of other small birds, for incubation and rearing

Strigiformes (owls)


- Head large and rounded
- Eyes large and directed forward, each in a disk of radial feather
- Ear openings large, often with flaplike cover
- Beak short
- Feet adapted for grasping
- Claws sharp
- Plumage soft-textured and lax
- Active chifly by night
- Carnivor (mammals, birds, also big arthropods)

Caprimulgiformes (nightjars)

- Bill small and delicate
- Mouth wide and margined with long bristlelike feathers
- Leggs and feet small and weak, not adaspted for grasping
- Plumage soft und lack
- Active mostly at dusk and by night
- Food of night-flying insect
- Often do not build nests

Apodiformes (swifts family Apodidae)

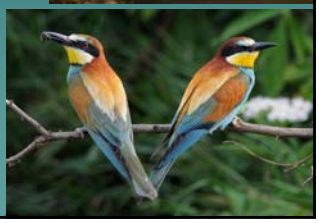
- highly aerial birds
- Legs very short and feet very small, all digit forward
- Many unable walk
- Wings pointed
  - strong fliers because they have thick shoulder bones and long, powerful breastbones
- Bill small and weak
- Active by day
- Insectivor

Apodiformes (family **Trochillidae)**

- some taxonomists have separated them into their own order, Trochilliformes
- Bill slender with long tubular tongue (hummingbirds)
- drink nectar

Coraciiformes (kingfishers motmots, bee eaters, rollers and hoopoes)

- Beautiful birds
- Large heads, short necks, somewhat short toes
- Third and fourth toes fused at base (syndactylous)
- Bill strong



Coraciiformes (Hornbills family Bucerotidae)

- tropical and sub-tropical Afrika and Asia
- a long, down-curved bill which is frequently brightly-coloured and sometimes has a casque on the upper mandible

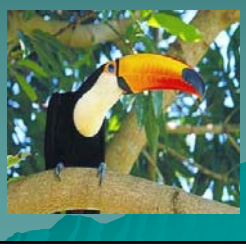
Piciformes (woodpeckers - family Picidae)

Arboreal birds

- tail feathers stiff with pointed tips
- bill stout, awllike
- tongue roughened or with barbs near tip and protrusible
- toes 2 in front and 2 (or 1) behind, not reversible
- cling to treetrunks, dig insects of wood
- arb

Piciformes (Toucans - family Ramphastidae)

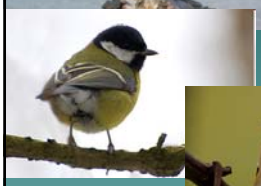
- birds from the neotropics (south America)
- brightly marked and have large, colorful bills

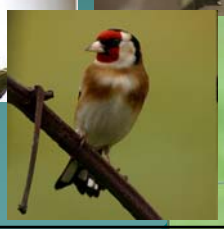


Passeriformes (passerines, songbids)

- Toes 3 in front and 1 behind, adapted for perching, anizodactyl,no reversible, no united
- Have complex muscles to control their syrinx (only oscines, passeres)
- Bills vary greatly in size and shape due to the type of diet of each species
- Many gape in the nest as infants to beg for food
- Most passerines are smaller than typical members of other avian orders
- many families and species in the world

suborder Oscines have the best control of their syrinx muscles among birds, producing a wide range of songs and other vocalizations





twice diverse order of terapods (the largest is mammal order Rodentia)