Birds
What is a bird?

- Endothermic, vertebrate
  - High metabolic rate
  - Four chambered heart
- Beak with no teeth
- Bipedal
  - Arms modified as wings
- Lays egg with hard outer shell
- Strong, light weight skeleton
- Sister to Crocodiles
  - Diverged in Late Jurassic
    - ~ 160 mya
Evolution of Birds

- Evolved from theropod dinosaurs
- Early feathers used for insulation, camouflage, attraction
  - Arms too short
  - Bodies too heavy

- Key adaptations for flight
  - Reduction an fusion of digits
  - Hollow bones
  - Fusion of clavicles (furcula)
  - Feather development
    - Closed with barbules and hooks
    - Asymmetrical feathers (flight)
  - Loss of teeth
  - Reduction of bony tail (pygostyle)

- Modern birds diverged ~150 mya
Archaeopteryx lithographica

Reptile Features
- Three claws on wing
- Flat sternum
- Ribs
- Jaw bones with teeth
- Long, bony tail

Modern Bird Features
- Flight feathers
  - Asymmetrical
- Wings
- Furcula
- Fusion of metacarpals and phalanges
- Larger braincase
# Similarities of Birds to Mammals and Reptiles

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Reptiles</th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occipital condyle</td>
<td>One</td>
<td>One</td>
<td>Two</td>
</tr>
<tr>
<td>Lower jaw bones</td>
<td>Several</td>
<td>Several</td>
<td>One (mandible)</td>
</tr>
<tr>
<td>Inner ear bones</td>
<td>One (stapes)</td>
<td>One (stapes)</td>
<td>Three (malleus, stapes, incus)</td>
</tr>
<tr>
<td>Ankles</td>
<td>Sited in tarsus</td>
<td>Sited in tarsus</td>
<td>Between tibia and tarsi</td>
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<tr>
<td>Red blood cells</td>
<td>Nucleated</td>
<td>Nucleated</td>
<td>Non-nucleated</td>
</tr>
<tr>
<td>Heart</td>
<td>Three-chambered (except crocodilians)</td>
<td>Four-chambered</td>
<td>Four-chambered</td>
</tr>
<tr>
<td>Thermoregulation</td>
<td>Ectothermic</td>
<td>Endothermic</td>
<td>Endothermic</td>
</tr>
<tr>
<td>Reproduction</td>
<td>Oviparity (most)</td>
<td>Oviparity</td>
<td>Viviparous (most)</td>
</tr>
<tr>
<td>Egg shell</td>
<td>Leathery</td>
<td>Hard</td>
<td>Leathery (monotremes)</td>
</tr>
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Anatomy of the Feather

- **Calamus**: smooth base of feather that extends into follicle
- **Rachis**: main shaft of feather
- **Barbs and barbules**: lateral branches off of the rachis, barbules contain hooks
- **Vane**: flat surface on each side of the feather, made up of barbs and barbules held together by the hooklets
# Types of Bird Feathers

**Pennaceous feathers** (vaned)
- Contour feathers: cover body, protection,
  - Remiges: flight feather on wing
  - Retrices: flight feathers on tail

**Plumulaceous feathers** (lack hooklets)
- Semiplume: under contour feathers, insulation
- Filoplume: under contour feathers, sense position of contour feathers
- Bristle: stiff rachis and typically lack barbules, protect eyes and face, sensory
- Downy: under contour feathers, insulation
Evolution of the Feather

- Initially believed to have evolved from scales
  - Keratin
- Evolved for insulation, co-opted for display and later flight
  - Exaptation

Five stages of feather development

1. Single filament with hollow shaft
2. Tuft of filaments with hollow shaft
3. Filaments fuse to form a solid shaft, stem from shaft
4. Barbules stem from barbs
5. Barbules develop hooklets that interlock adjacent barbs, asymmetrical shape in flight feathers
Feather Growth and Development

1. Formation of dermal papilla

2. Formation of follicle

3. Formation of epidermal ridges
   - Ridges form into barbs and barbules

4. Open feather
   - Corneal sheath degenerates
Feather Function

- Flight
- Insulation
  - Downy feathers
  - Nesting material
- Heat absorption
- Mate attraction
- Camouflage
- Protection from elements
Plumage Coloration

- **Biochrome pigments**: naturally occurring chemical compounds that reflect certain wavelengths of light
  - Melanins: browns, black, beige, gray
  - Carotenoids: red, yellow, orange
    - Derived from diet
  - Porphyrin: bright brown, green, magenta

- **Structural coloration**
  - **Constructive interference**: microscopic structures within the feather reflect certain wavelengths of light
    - White, blue, green, red, iridescent feathers
Molting

**Molting**: the normal shedding and replacement of worn feathers by a new set of feathers

**Benefits**
- New, bright feathers for breeding
- Reduction of parasite load

**Costs**
- Energetically demanding
- Susceptible to predation
Bird Anatomy: Adaptations for Flight

- **Furcula**: fused clavicles that compress and rebound down stroke
- **Keel**: projection of sternum used in flight muscle attachment
- **Synsacrum**: fusion of caudal and lumbar vertebrae. Absorbs shock when landing
- **Pygostyle**: fused tail vertebrae that supports and controls tail feathers
- **Carpometacarpus**: fusion of hand and wrist bones for strength
- **“Hollow” bones**: long bones have air pockets and are reinforced with struts
Both flight muscles attached to keel

**Downstroke**
- Pectoralis muscle contracts
- Attached to ventral side of humerus

**Upstroke**
- Supercoracoideus muscle contracts
- Attached to dorsal side of humerus by tendon
Theories on the Evolution of Flight

Wing-assisted incline running
- Arms with feathers aided in running up an incline

Cursorial theory
- Elongated limbs with feathers increased leaping ability

Arboreal theory
- Elongated limbs and feathers aided in gliding or parachuting from trees
Bird Anatomy: Types of Feet

- **Most songbirds**: Anisodactylie
- **Emu**: Zygodactylic
- **Woodpecker**, **Ostrich**: Didactylic
- **Hallux**
Respiration in Birds

- **One-way breathing**
  - Two respiratory cycles
  - No residual air left in lungs
    - Lungs constantly receiving fresh air with high $O_2$ content

**Sequence of respiration in birds**

1. Inhaled air passes through primary bronchi to posterior air sac
2. Exhalation moves inhaled air from posterior air sacs to lungs
3. Air is inhaled again. Oxygen depleted air moves from lungs to anterior air sacs
4. Second exhalation moves air from anterior air sacs, bronchi and trachea into the atmosphere
Bird Digestion

- **Crop**: food storage
- **Proventriculus**: glandular stomach, secretes mucus, HCl, and pepsinogen
- **Gizzard**: mechanical breakdown of food
- **Small intestine**: three sections (duodenum, jejunum and ileum). Nutrient absorption
- **Large intestine**: short, water absorption
- **Caeca**: site of fermentation in some birds
- **Cloaca**: common opening for digestive, urinary and reproductive systems
Thermoregulation in Birds

Response to heat stress

- Hyperthermia (elevated body temp)
- Panting (Gular Flutter)
  - Terns and gulls
- Change rate of venous blood returning from skin
- Cutaneous water loss
  - Directly through skin
- Evaporative cooling
  - Storks and vultures poo on legs
- Reduced activity during day
Thermoregulation in Birds

Response to cold stress

- Fluff feathers for added insulation
- Shivering
- Increase metabolic rate
- Huddling
  - Penguins and nuthatches
- Torpor (facultative hypothermia)
  - Hummingbirds
- Manipulate blood circulation to fee
Bird Behavior: Migration

- More than half of North American birds (650 species) are migratory

- Move from areas with low or decreasing resources to areas with more resources
  - Food and nesting locations

- Timing initiated by changes in day length

- Long distance migrants directed by earth's magnetic field, visual cues, stars

- Resting areas
  - Provide food to fuel migration
Types of Migrants

Residents: stay in same location year round
- Adequate resources to survive

Short distance migrants
- Higher elevations to lower elevations in winter

Long distance migrants
- Typically move from breeding ranges in Northern U.S. and Canada to wintering grounds in Central and South America
  - Four main flyways
- Longer days and more insects in northern latitudes during summer
  - Larger clutch sizes
Bird Behavior: Flocking

**Flock:** congregation of birds usually in flight or foraging

**Advantages**
- Foraging – finding food
- Protection – predator detection, mobbing
- Mating – increased selection of mates
- Chick rearing – protection from predators
- Aerodynamics – less air resistance
- Warmth – share body heat

**Disadvantages**
- Visibility – attract predators
- Competition – competition for food and mates
- Disease – higher densities = greater disease transmission
Attracting a Mate

Unique behaviors are the result of sexual selection

- **Song**: song performance depicts male quality. Territorial defense
  - Most songbirds

- **Displays**: male performance and ornamentation demonstrate male quality
  - Good-genes hypothesis
  - Birds of paradise

- **Lek**: communal display area where males perform for females
  - Grouse

- **Constructing a nest**: nest quality related to male quality
  - Bower birds
Breeding Systems in Birds

- **Monogamy**: neither sex has opportunity to monopolize additional mating partners
  - Most common mating system in birds
  - Shared parental care maximizes reproductive success

- **Polygamy**: multiple mating partners
  - 3% of birds species

- **Polygyny**: Males control or have access to two or more females
  - 2% of bird species

- **Polyandry**: females gain access to multiple males
  - <1% of bird species

- **Polygynandry**: several females and several males form a communal breeding unit
  - Male parental effort related to confidence of paternity
Nesting Cycle

- Find place to breed
  - Territory
- Find mate
  - Display, singing
- Nest building
- Copulation and egg formation
  - One egg per day
- Egg laying
  - Occurs over multiple days
- Incubation
  - Brood patch
- Hatching
  - Timing controlled by incubation
- Feeding young
  - Both sexes feed young, ~ 2 weeks
- Fledging
  - Fledglings stay with parents for ~2 weeks outside of nest
Bird Behavior: Songs and Calls

- Produced by the syrinx

- **Calls**: short, simple vocalizations given by either sex
  - Distress, flight, warning, feeding, nesting
  - Found in most birds

- **Songs**: longer and more complex than calls. Used in territorial male birds
  - Found in only three orders or birds
    - Caprimulgiformes (hummingbirds)
    - Passeriformes (song birds)
    - Psittaciformes (parrots)
Types of Nests

- **Scrapes**: small depression in the ground
  - Shorebirds, gulls, terns, vultures

- **Burrow nests**: burrows or holes dug into the ground
  - Burrowing owls, kingfishers, bank swallows

- **Cavity nest**: nest constructed in a chamber, typically in a tree trunk
  - Woodpeckers, bluebirds, parrots, some ducks

- **Cup nest**: cup-shaped nest constructed using grasses, twigs, spider silk, saliva, mud
  - Most passerines (song birds), hummingbirds

- **Platform nest**: large nests built on large trees or structures
  - Hawks, eagles, osprey

- **Pendant nest**: elongated sac woven from grasses and plant material and suspended from a branch
  - Bushtits, orioles, weavers
Brood Parasitism

Brood parasitism: the practice of laying eggs in another individual’s nest to pass the cost of rearing the offspring off on another individual

- Reduced reproductive success of host

- Intraspecific parasitism
  - Many waterfowl, pigeons, doves and songbirds

- Interspecific parasitism
  - Brown-headed cowbird, Common cuckoos
  - Threat to many songbird species
Bird Development

- **Altricial**: young are immobile, lack down and have closed eyes after hatching
  - Essential parental care
  - Fast growth

- **Precocial**: young are mobile, have downy feathers, and open eyes after hatching
  - Minimal parental care (self-feeding)
Perching Birds

- **Perching**
  - A tendon behind the tibiotarsus allows for the weight of the bird sitting to tighten on the perch.
  - This locks the foot shut.
Bird Phylogeny

- Ratites
- Carinates

[Diagram showing bird phylogeny with examples of ratites and carinates]
Bird Phylogeny