Structural and Functional Adaptations for Flight

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Spindle-Shaped Body:

- It is designed to offer minimum resistance to the wind.

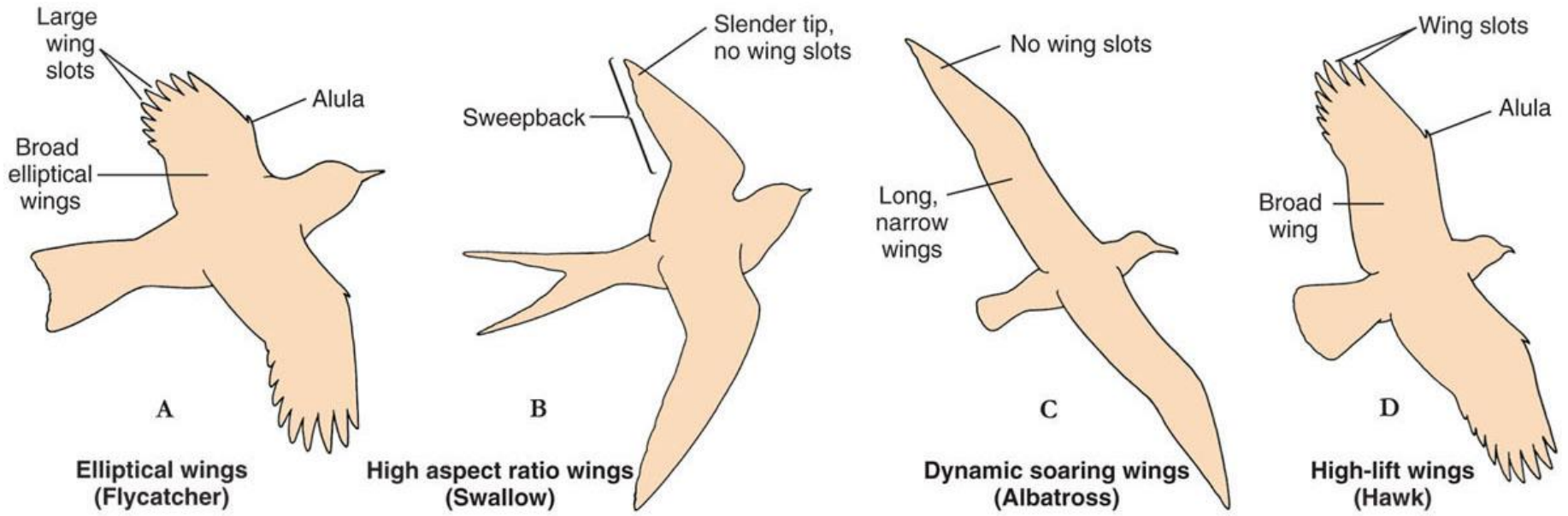
Warm-Bloodedness:

- Birds are warm-blooded animals which is necessary for flight.

Wings:

- Fore-limbs are modified into wings, which help during flight.

4 Basic Forms of Bird Wings



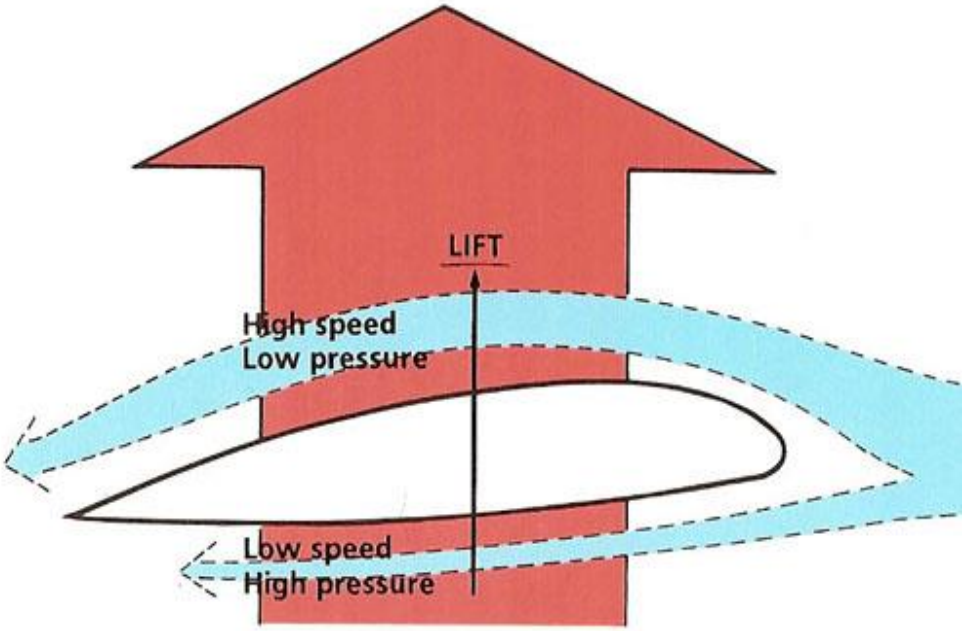
A. Slotted wing tip Prevents stalling, and quick maneuvering

B. Long Migration birds

C. Soaring, poor Maneuvering, Strong to handle ocean winds and currents

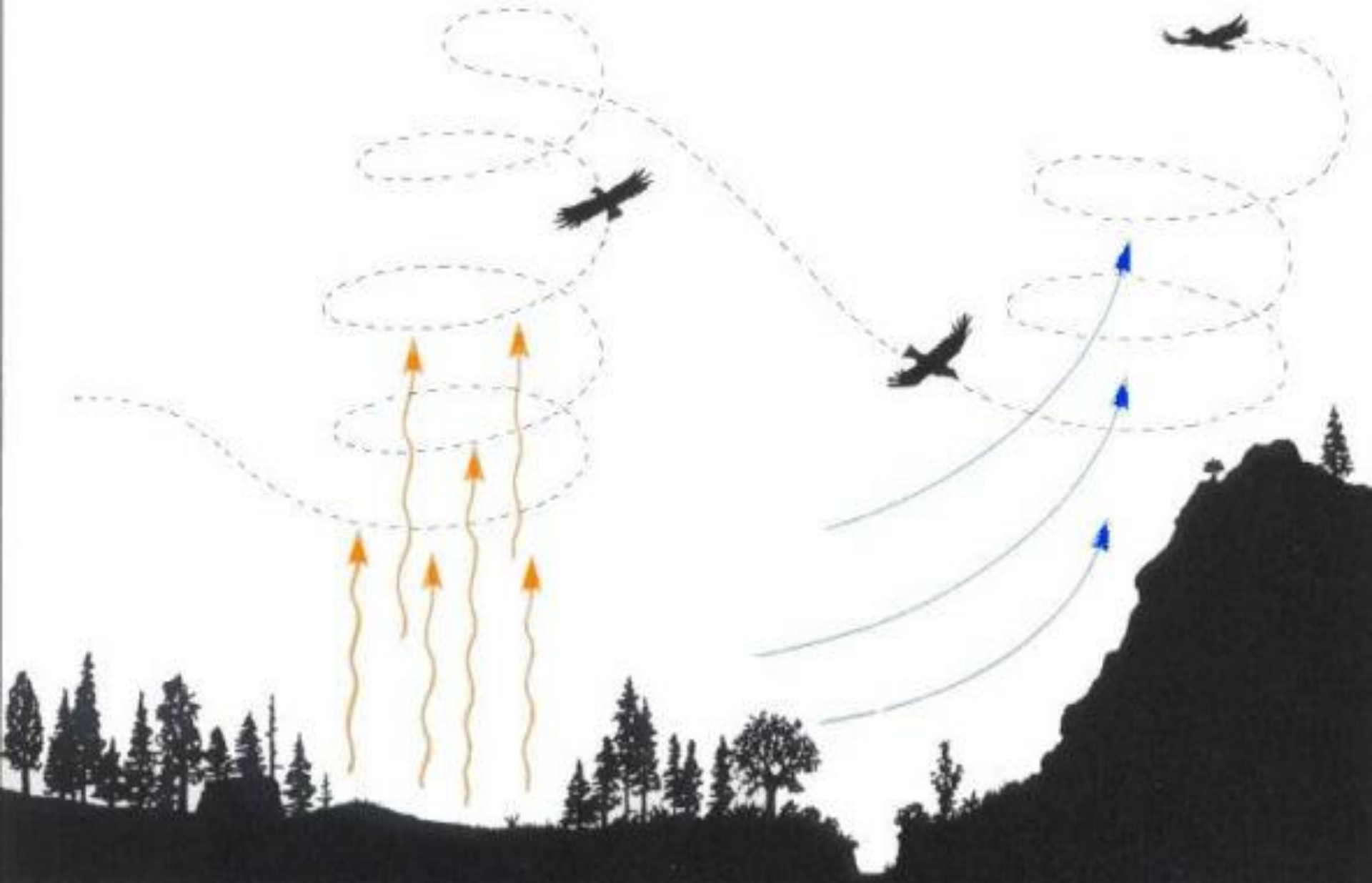
D. High lift, slow speed, Land Soarers

- Air moving above the wing moves faster causing the molecules spread out more than the air below



Air under the wing moves more slowly and is slightly squashed so it is at a higher pressure than the air above the wing.

Soaring Flight



Feathers:

- **Light weight**, **strong** and **modified scales,** Made up of keratin
- provide the **passage for air** and **reduce friction** to minimum.
- **prevent loss of heat** and help to maintain a constant temperature.

Flight feathers: (modified Contour)
Found on wings & tail, provide lift for flight

- **Molting**
  - Fully-grown feather is a dead structure
  - Shedding or molting is a gradual process that avoids leaving bare spots
  - **Flight and tail feathers are lost in pairs,** one on each side, to maintain balance

  - In some species, *replacement is continuous*
    - Flight is unimpaired
  - *In many water birds,* primary feathers are molted all at once
    - Birds are temporarily grounded

  - Most birds **molt once a year,** usually in late summer after the nesting season

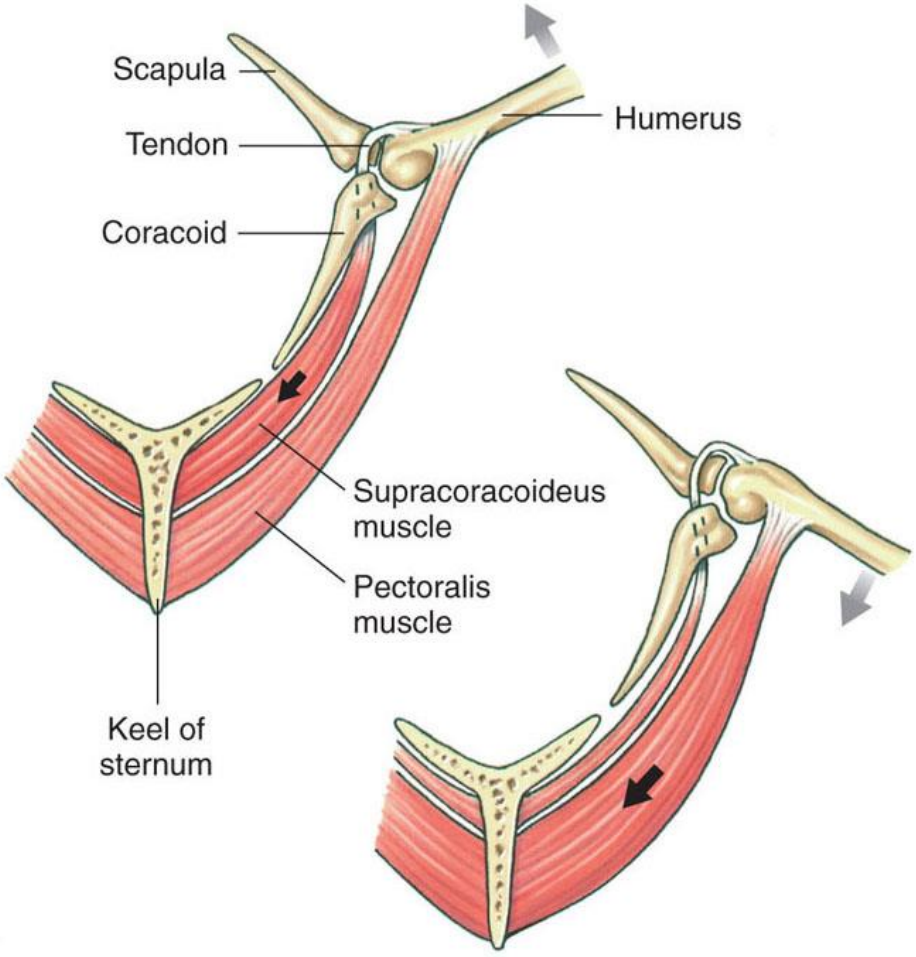
Flight Muscles:

- Except in flightless birds
  - Sternum bears a large keel to anchor flight muscles which help in flight.

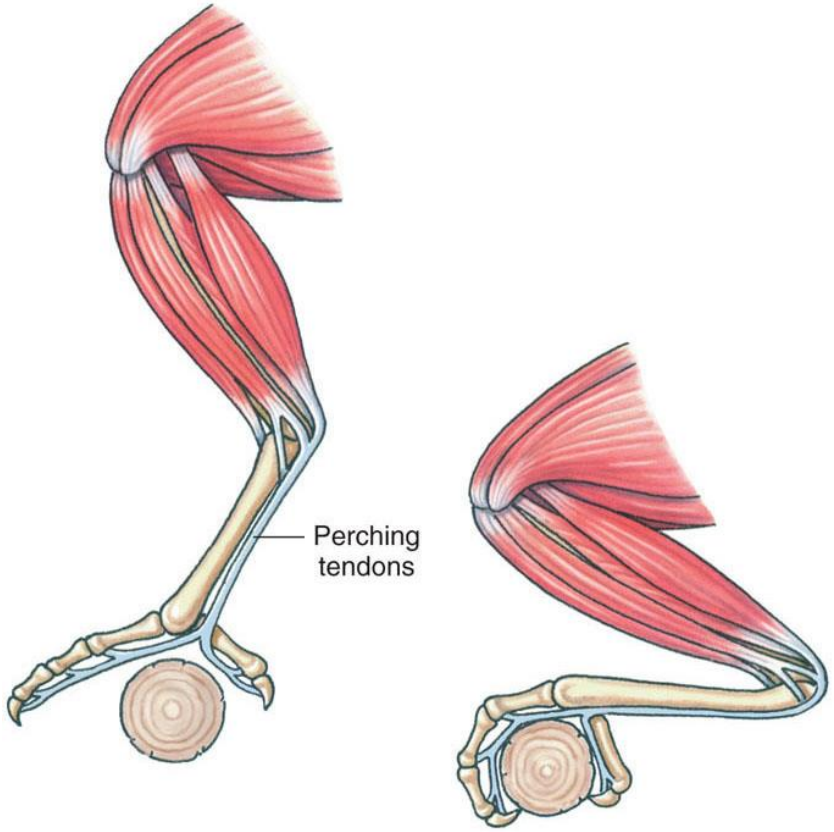
Muscular System

- Pectoralis muscles

- Supracoracoideus muscle



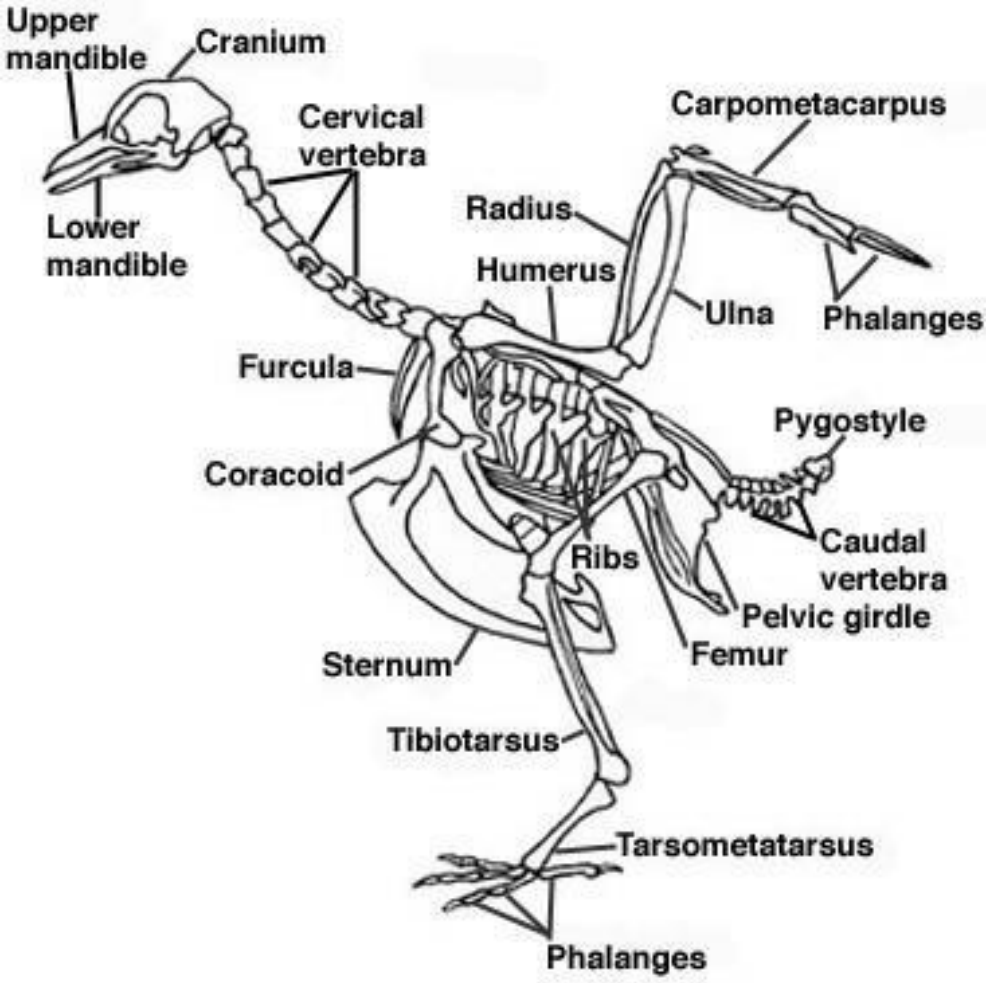
- Main leg muscle mass is in thigh with connections by long tendons to feet and toes
- **Toe-locking mechanism** prevents a perching bird from falling off a branch while asleep
- As many as **1000 muscles** may control the tail feathers for **steering in flight.**



Tendons automatically tighten, closing toes around the perch

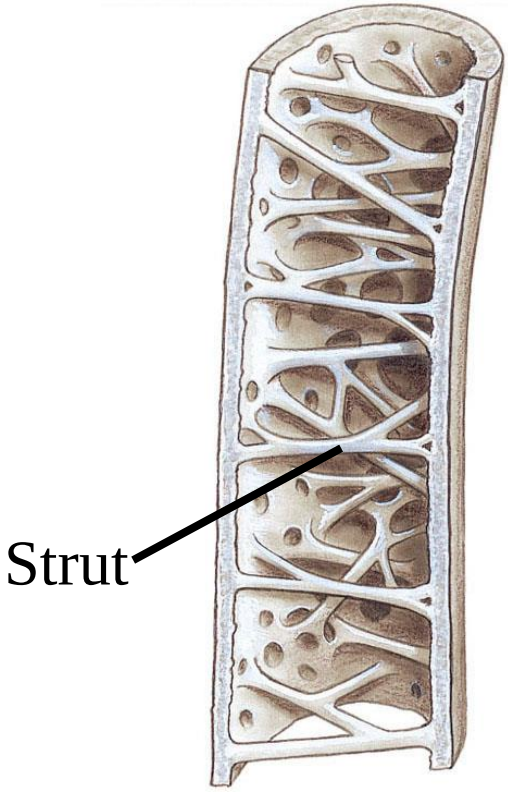
Skeletal structure

- Enlarged sternum
  - Flight muscle attachment (breast)
- Long neck
  - Counter-balance against the beating of wings during flight
- Elongated carpals & metacarpals
  - Lengthens wing span



Bones

- Most of bones are pneumatic and filled with air instead of bone marrow. It makes the body light without sacrificing strength along the axis of the bone.
- The bone is much more susceptible to pressure from the side
- Most of bones are firmly fused together, which help in flight.



Hollow wing bone (Pneumatized) shows Struts and Air spaces

Respiratory System

- Differs radically from lungs of reptiles and mammals

Bird Lungs

- Finest branches of the bronchi do not terminate in alveoli but are tube-like *parabronchi*

Air sacs

- An air sac system helps *cool bird during vigorous exercise* when up to 27 times more heat is produced
- Air sacs extend into bones, legs and wings, *providing considerable buoyancy*

- Highly efficient lungs able to remove 31% of oxygen from each breath vs. 24% in humans
- Needed to sustain muscles during flight

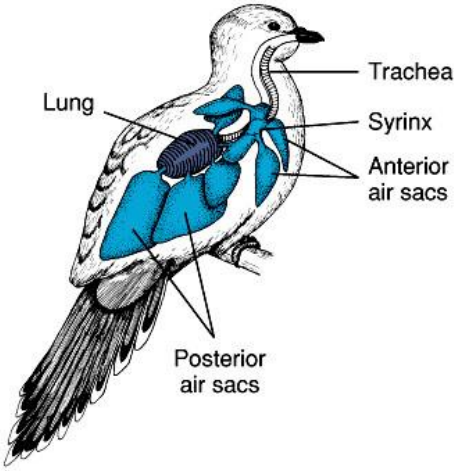
– Large portion of air bypasses lungs and flows directly to posterior air sacs on inspiration

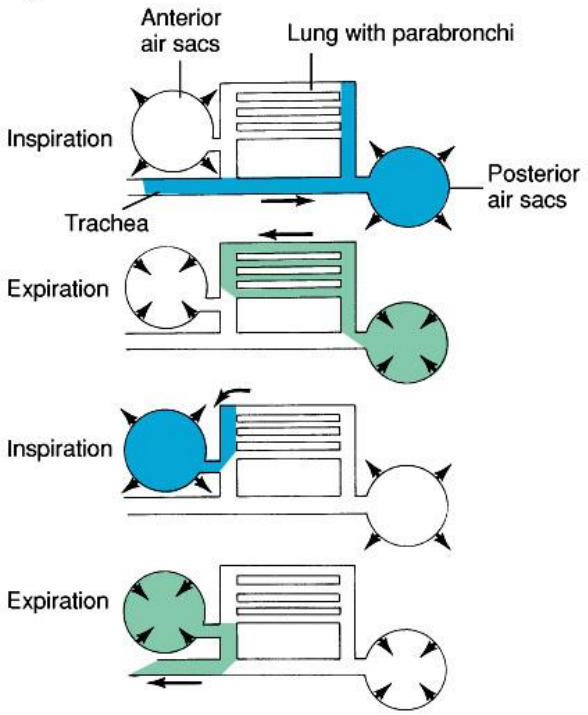
– On expiration, oxygenated air flows through lungs

- Continuous air flow to anterior air sacs, then exits

– Takes 2 respiratory *cycles* for a single breath of air to pass through system

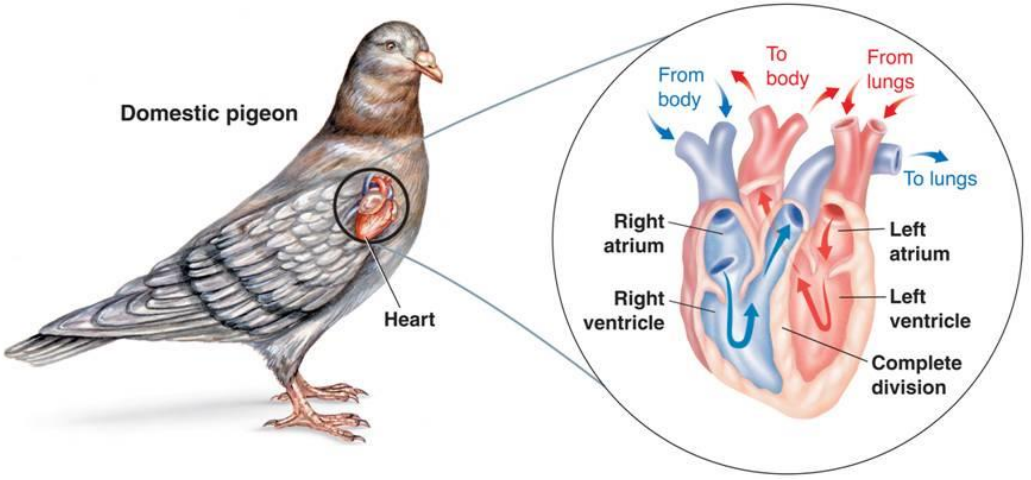
– *Most efficient respiratory system of any vertebrate*





Circulatory System:

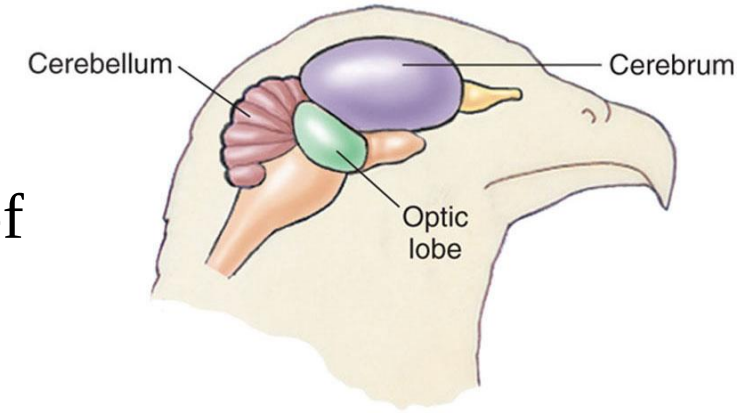
- A large oxygen supply is required for rapid metabolism and warm-bloodedness.
- It is done by an efficient circulatory system.



- Heartbeat relatively fast compared to mammals and *inversely proportional to size*
  - Turkey heart beats 93 times per minute
  - Chicken heart beats 250 times per minute
  - A small black-capped chickadee heart beats 500 times per minute

Nervous and Sensory Systems

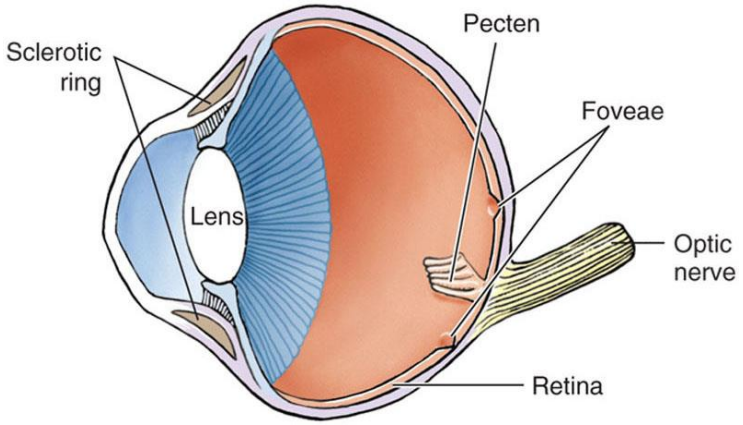
- Bird's brain has *well-developed cerebral hemispheres, cerebellum and midbrain*
- Equilibrium is maintained by cerebellum of the brain.



Have *good hearing and superb vision*

- Best in the animal kingdom
- Although sense of smell and taste is poor in most

- **Ear** is similar to that of mammals
  - External ear canal leads to an eardrum
- **Eye** is similar to mammal eye, but it is larger for a relative to body size
  - *Less spherical and almost immobile*
    - Bird turns its head rather than eyes
  - *Has both rods and cones*
    - Diurnal birds have more cones
    - Nocturnal birds have more rods



Hawk Eye: Pecten nourishes retina
Cone cells on Foveae- 1.5 million for hawk, 0.2 million for human
Allows for better vision

Absence of Urinary Bladder:

- Except Rhea, urinary bladder is absent in birds.
- Excreta are passed out at once. This helps in reducing the weight of the body.

Excretory System

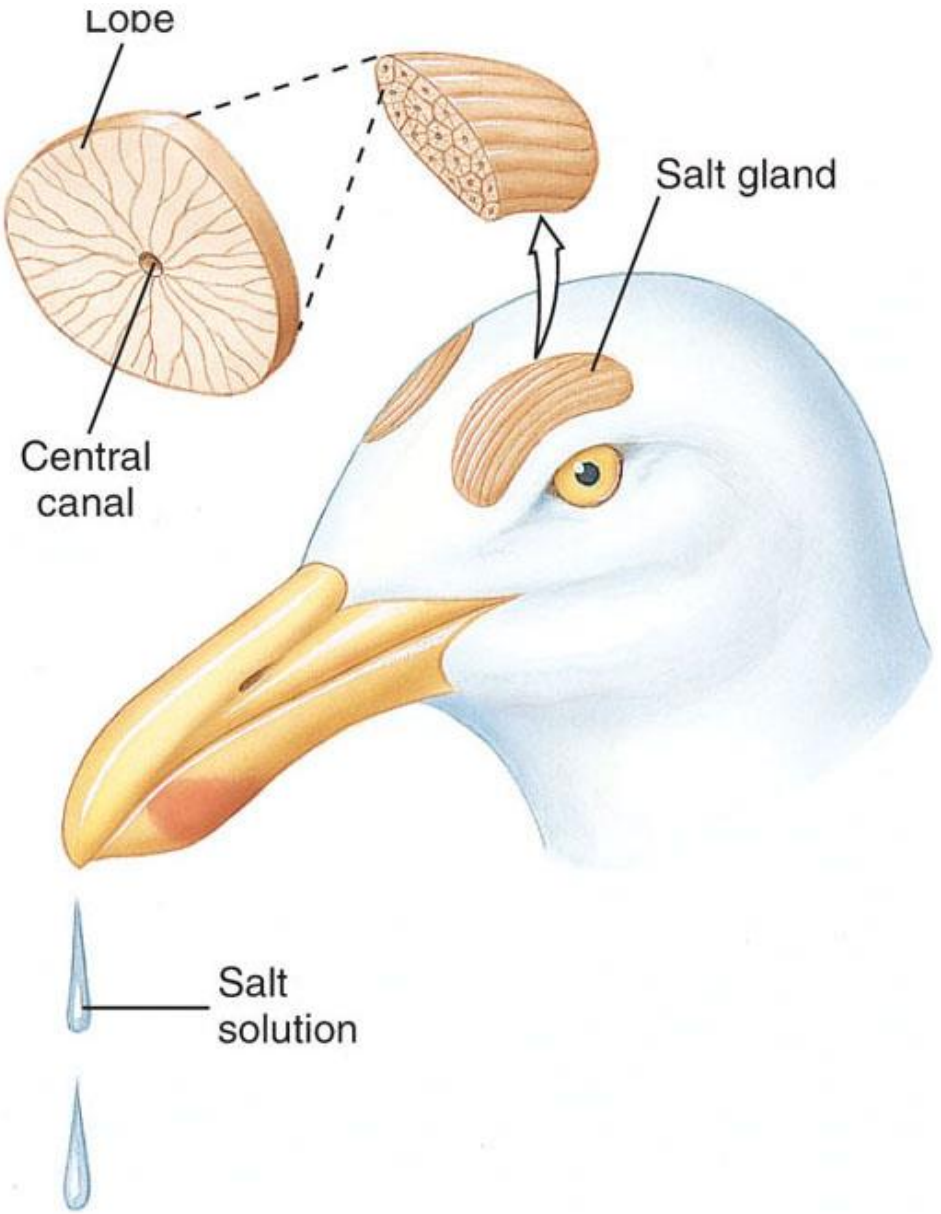
- Pair of large *kidneys* is composed of many thousands of nephrons
- Birds use *vertebrate pattern of glomerular filtration and selective resorption*
- Urine flows through *ureters* to the *cloaca*
- *Uric Acid*
  - Birds use the reptilian adaptation of excreting nitrogenous wastes as uric acid

- *Marine birds*

– *Salt glands*

– Salt solution runs out the nostrils

– Gulls and other sea birds have a perpetual “runny nose”



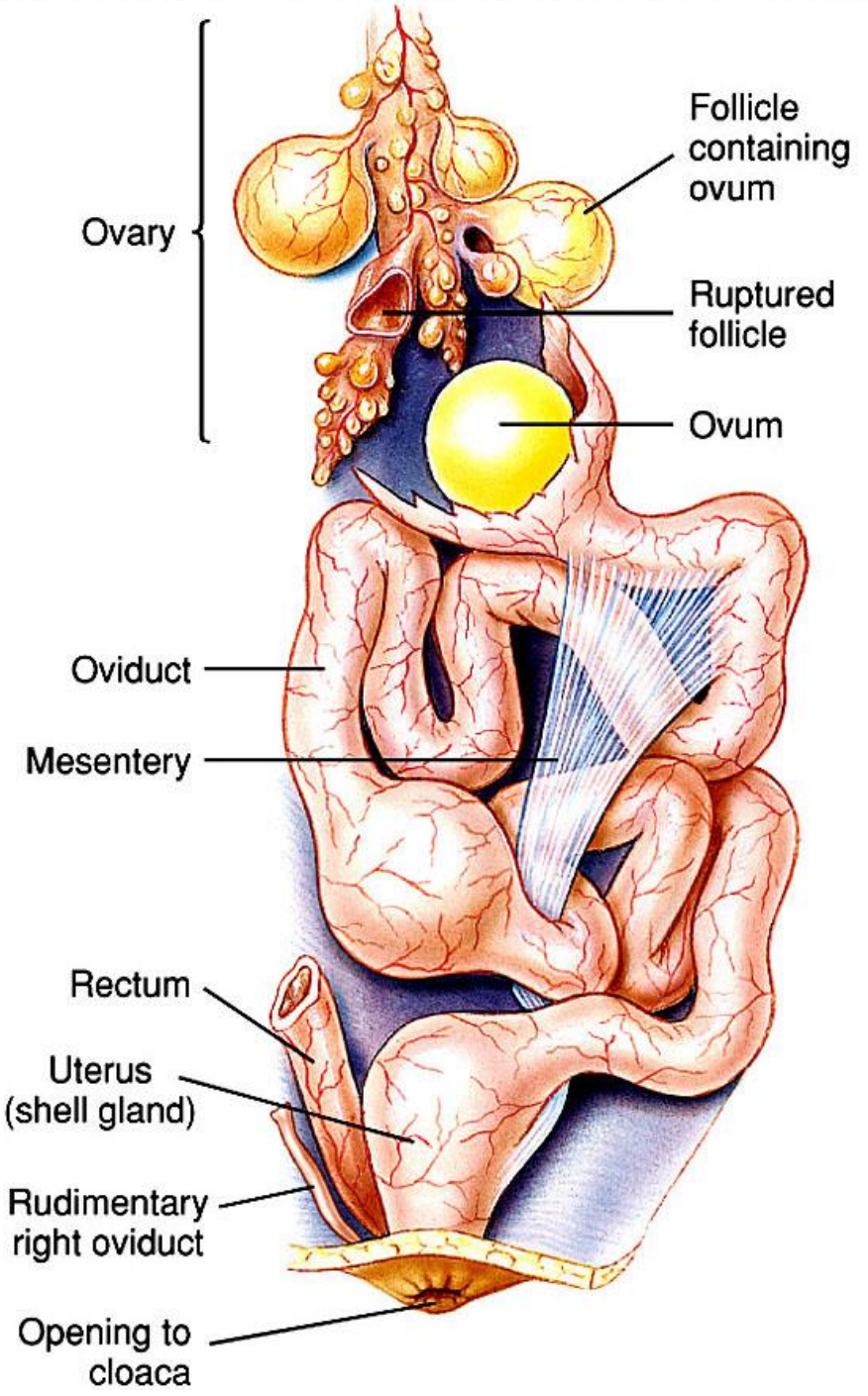
Reproductive System

- **Males** mostly *lack a penis*
  - Mating by *cloacal kiss*

- *Testes* are very small until the approach of the breeding season
  - *May then enlarge 300 times*

- Before discharge, sperm are stored in a greatly enlarged *seminal vesicle*

- In most **female birds**, left ovary and oviduct develop and *right ovary and oviduct degenerate*



- Body weight is further reduced by reducing or losing certain structures and organs
  - No teeth
  - Reduced large intestines