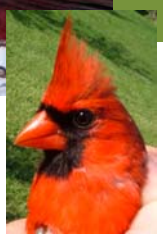


Molt

Molt

- Replacement of Feathers
- Scheduled
  - Annual Molt
- Unscheduled
  - Fright molt, predator event

Molt

- Natal Plumage (at first hatching)
  - Psilopaedic
    - A few scattered down feathers
  - Ptilopaedic
    - Dense, fuzzy down feathers

Molt

- Soon replaced by more substantial down
  - Same follicles in some species, different in others
- In a few weeks, juvenile feathers begin

Molt

- Juvenile Feathers replaced by adult plumage
- Adults molt after breeding
  - May molt before breeding

Molt

- Feather wear can function like molt

Molt Terminology

- Basic Plumage = Non-breeding (winter)
- Alternate Plumage = Breeding (summer)

- Molts are named for the new plumage:
  - e.g., going from basic to alternate plumage is pre-alternate molt

Molt Terminology

Age	Molt	Plumage
0 – 1 month	Prejuvenal Molt	Juvenal
1 – 3 months	First Prebasic Molt	Basic 1
8 – 10 months	First Prealternate Molt	Alternate 1
1 + years	Second Prebasic Molt	Basic 2
1 + years	Second Prealternate Molt	Alternate 2

Molt Terminology



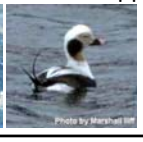


Molt Terminology

- One molt is probably the primitive condition
  - Molt is energetically demanding
  - 1 molt/year keeps up with normal feather wear
- Species in harsher environments molt more
  - Also removes parasites

Molt Terminology

- Some species have 3 or even 4 partial molts per year
- Some ducks lose all flight feathers simultaneously
  - Very vulnerable for a few weeks
- Oldsquaw has three overlapping partial molts


Art Morris


Arthur Grosset

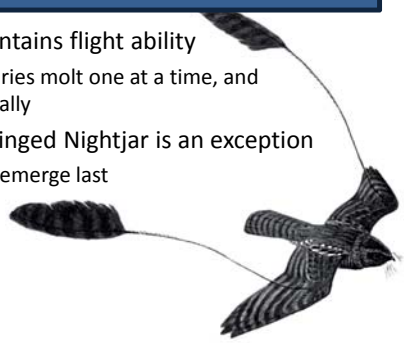
Molt Sequence

- Usually maintains flight ability
  - e.g., primaries molt one at a time, and symmetrically


Whitefish Point Bird Observatory

Molt Sequence

- Usually maintains flight ability
  - e.g., primaries molt one at a time, and symmetrically
- Standard-winged Nightjar is an exception
  - Standards emerge last



Central Avian Adaptation

- Birds have mastered all forms of flight
  - Hovering, diving, flying upside down, soaring
- Many components to flight:
  - Taking off, maneuvering, stabilizing, landing
- Constant adjustments
  - Filoplumes

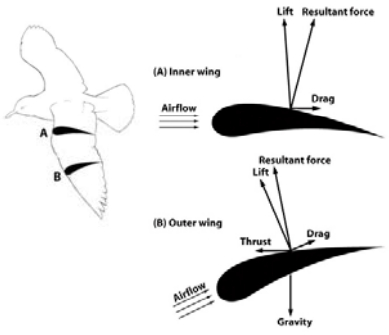
Energetically Expensive

- Takes a lot of energy to take off
- More efficient overall
  - 10 gram bird uses < 1% of the energy to travel over a distance compared to a 10 gram mouse
- Strong selection for maximum efficiency

Aerodynamics

- Gravity and drag must be overcome
  - Gravity = weight
  - Drag = turbulence + friction
- Lift (up) and thrust (forward)

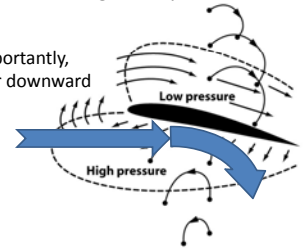
Aerodynamics



Aerodynamics

- Wings change the pattern of air circulation
  - Faster moving = less pressure (Bernoulli principle)

More importantly, moves air downward



↑ Lift

Aerodynamics

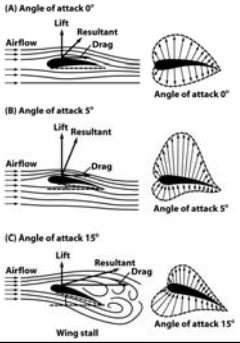
- Amount of lift increases due to:
  - Airspeed
  - Deflected air volume (wing area)
- Lift needed for take-off can come from wind, jumping from a height, or from running

Aerodynamics

- Angle of Attack
  - Orientation of wing to airflow
  - Greater angle = Greater lift, until stalling

Aerodynamics

- Angle of Attack

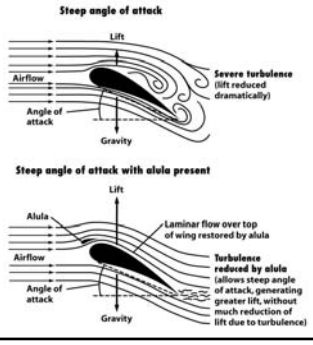


Aerodynamics

- Slotted Wings
  - Each primary becomes a little wing

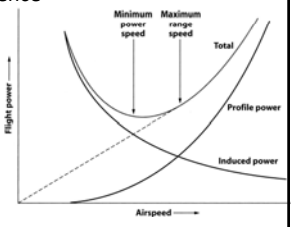
Aerodynamics

- Slotted Wings



Aerodynamics

- Drag
  - Profile Drag = friction
  - Induced Drag = turbulence
  - At high airspeed:
    - Profile Drag increases
    - Induced Drag decreases



Aerodynamics

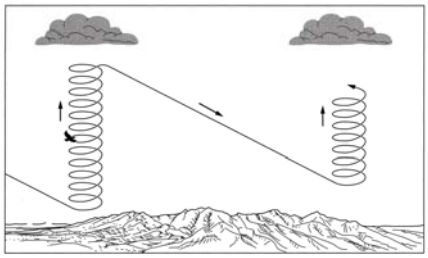
- Peregrine Falcon

Aerodynamics

- Flying in Formation
  - Reduces induced drag

Kinds of Flight

- Soaring and Gliding
  - Use rising air: **thermals** and updrafts



Kinds of Flight

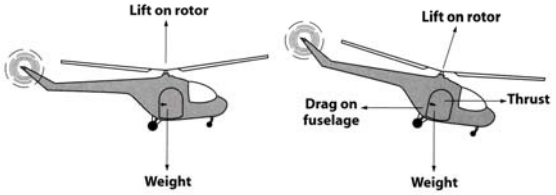
- Soaring and Gliding
  - Use rising air: **thermals** and updrafts

Kinds of Flight

- Soaring and Gliding
  - Use rising air: thermals and **updrafts**

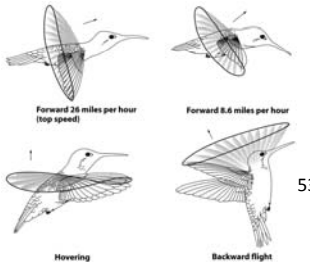
Kinds of Flight

- Flapping
  - Thrust generated by primaries



Kinds of Flight

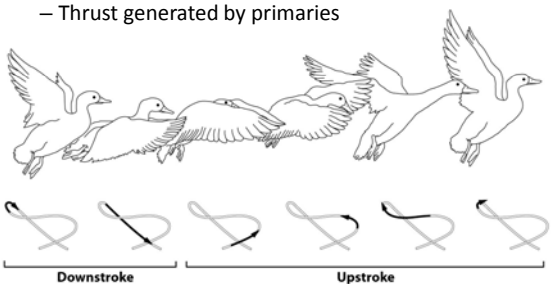
- Flapping
  - Thrust generated by primaries



53 beats/second

Kinds of Flight

- Flapping
  - Thrust generated by primaries



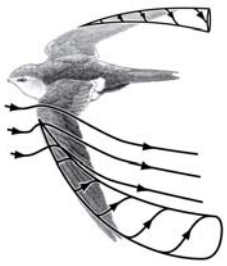
Kinds of Flight

- Flapping
  - Thrust generated by primaries
- Wings are independent
- ~50 muscles control wing movements
- Birds increase speed by increasing thrust, not frequency

Kinds of Flight

- Flapping
  - Thrust generated by primaries

Leading-edge Vortices



Kinds of Flight

- Birds have well-controlled landings

Kinds of Flight

- Tail Functions
  - Steering and Braking
  - Add lift by improving airflow and reducing turbulence

Kinds of Flight

- Intermittent Flight
  - Flapping and Gliding
    - Cooper's Hawk
  - Flapping and Retracting Wings
    - Woodpeckers

Flight Comparisons

	Plane	Bird
Speed (body lengths/second)	32	140 swift
Roll (degrees/second)	720	5000 Barn Swallow
G forces	8-10	10-14

Wing Size and Shape

- Wing Loading
  - Wing area to body mass ratio (g/cm^2)

Wing Size and Shape

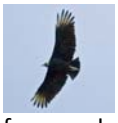
- Wing Loading
  - Wing area to body mass ratio (g/cm^2)

Thick-billed Murre 2.6 g/cm^2

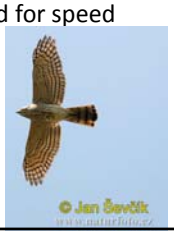
Yellow Warbler 0.1-0.2 g/cm^2

Wing Size and Shape

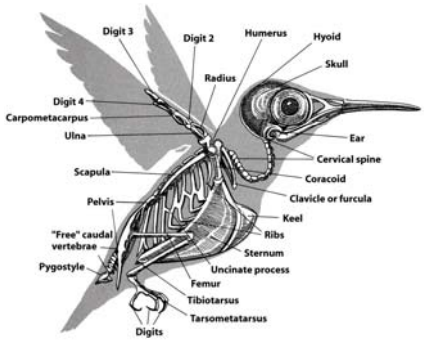
- Aspect ratio
  - Ratio of lift to drag



- Longer, more narrow wings good for speed and efficiency
  - Not good for maneuverability

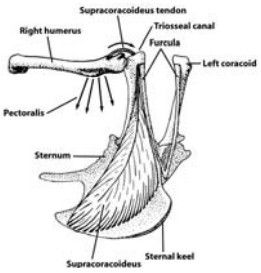


Skeleton



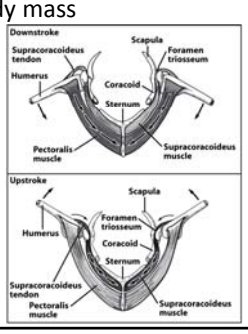
Skeleton

- Keel: muscle attachment
- Coracoid, scapula, furcula: resist pressure
- Uncinate Processes
- Fused hand bones
- Wing can fold
- Hollow Bones



Flight Muscles

- Pectoralis: 35% of body mass
  - Pulls wing down
- Supracoracoideus
  - Pull wings up



Flight Muscles

- Red Muscle vs. White Muscle
- Red
  - sustained power from aerobic respiration
- White
  - powerful short bursts through anaerobic metabolism

Flightless Birds

- Flight is a primitive character

  (all birds have wings)

Bones and muscles require energy

Some birds have lost the ability to fly, saving them energy investment

Common on islands without mammalian predators

Diving birds are less buoyant if they have smaller wings