The Modern, Western Dragon

Presented by me


Dragons?

“It is highly implausible for dragons to have evolved from any living or extinct creature”

- David A. Duchêne, evolutionary biologist at the University of Copenhagen

Dragon (Pathfinder)

- Body
  - 1 head, 4 legs, 2 wings, 1 prehensile tail
  - Scaly skin
  - Leathery, bat-like wings
- Abilities/Magic
  - Breathes some element
  - Spells
- Flight speed: up to 28.409 mph
- Lifespan: Immortal?
- Measures up to at least 64 ft in length and/or height
- Weighs up to at least 125 tons

Medieval European Dragon

- Body
  - 1 or more heads, 4 legs, 2 wings, 1 prehensile tail
  - Scaly skin
  - Leathery, bat-like wings
- Abilities
  - Breathes fire
- Traits:
  - Dwells in caves
  - Hoards treasure

Real Life Dragon?

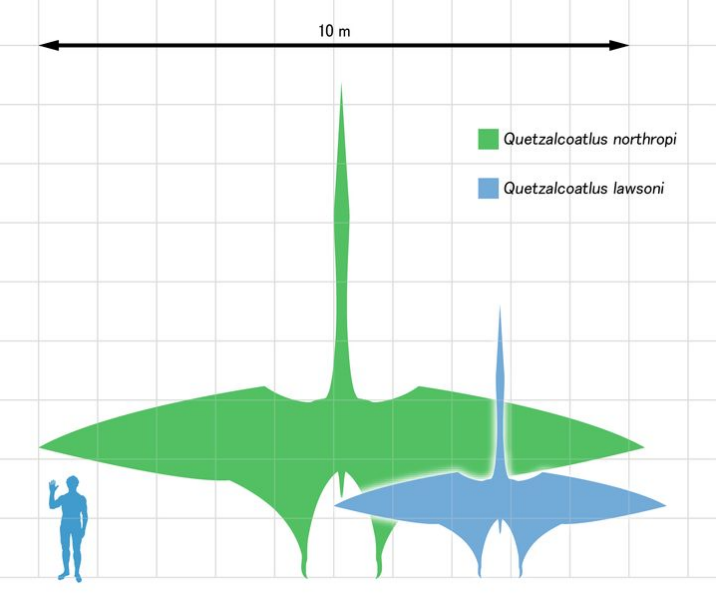
“If we discovered real fantasy dragons, I would expect that they were an ancient lineage somewhere in the middle, distantly related to early dinosaurs, early crocodilians, early ‘reptile’ lineages that ultimately gave rise to lizards and snakes and turtles”

- R. Alexander Pyron, Robert F. Griggs Associate Professor of Biology at George Washington University

Pterosaurs

- Body
  - 1 heads, 4 legs, 1 tail
  - Patagium wings stretching from ankles to lengthened fourth finger
  - Coats of hair-like filaments from simple to feather-like
- Flight speed: up to 75 mph
- Wingspan: 10 in. to 36 ft.
- Height: up to 19 ft.
- Weighs up to 550 lbs.
- Traits:
  - Endothermic
  - Hollow bones
- Evolved from archosaurs

Quetzalcoatlus (Pterosaur)



Q. northropi vs Cessna 172

Are Pterosaurs Dragons?

- Similar wing material
- Flies faster than a Pathfinder and D&D Dragon
- Much lighter than a dragon
- Similar size of a dragon
- No prehensile tail
- No separate limbs for wings
- No fire breathing

Fire Breathing

“This also makes me wonder what the adaptive function of the fire-breathing is — in any other animal, a behavior like that would be for defense/protection, but the dragon is so large that it likely doesn’t have any natural predators”

- Beth Reinke, assistant professor of biology at Northeastern Illinois University

Fire Breathing (Gas)

- Cold-blooded animals can generate electrical discharges
  - Electric eels can generate up to 860 volts
- Dragons could make a flammable gas in their digestive tract that they store in a gas bladder then discharge through their mouth or nose

“Fire” Breathing (Chemical)

- Chemical reactions can generate a lot of heat
- Chemicals stored in reservoirs can be combined and sprayed out
- Bombardier beetles
  - Chemicals: hydroquinone and hydrogen peroxide
  - Temperature: near boiling point of water
  - Propulsion: pressure and valve based
- Spitting cobras
  - Spits toxin as far as 6.6 ft
  - Very accurate and precise control of spit
  - Muscle squeeze propulsion

Fire Breathing (Magic)

- Magic can make fire

Thermoregulation

“The great group of reptiles called archosaurs were mostly warm-blooded and high-powered, so maybe dragons could be imagined as modified members of the archosaur group”

- Darren Naish, a paleozoologist

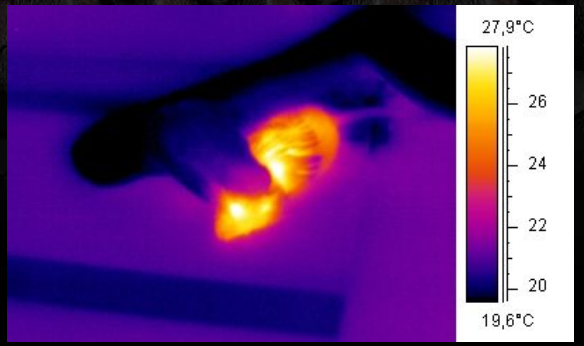
Warm vs. Cold Blooded

Ectothermic (cold-blooded)

- Metabolism
  - Unable to produce sustained high enough output for flight
- Produces low heat for gigantic body
- Existing cold-blooded animals can generate electricity for gas-based fire breathing

Endotherm (warm-blooded)

- Metabolism
  - Produces enough sustained energy to be fast, fly, and intelligent
- Too easy to overheat, especially at large sizes



Cold-blooded snake eating warm-blooded mouse

Flight

“The issue is that powered heavier-than-air flight is extremely difficult; dragons like the ones we see in fantasy would be unable to generate the lift forces necessary to move their massive bodies through the air”

- R. Alexander Pyron, Robert F. Griggs Associate Professor of Biology at George Washington University

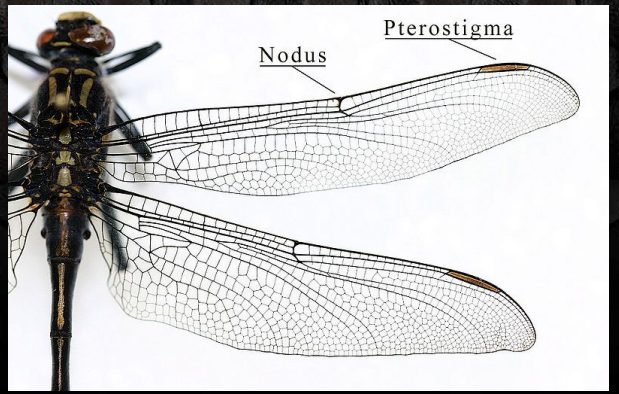
Problems with Dragon Flight

- Too heavy
- Not aerodynamic
  - Long necks
  - Spiky protrusions

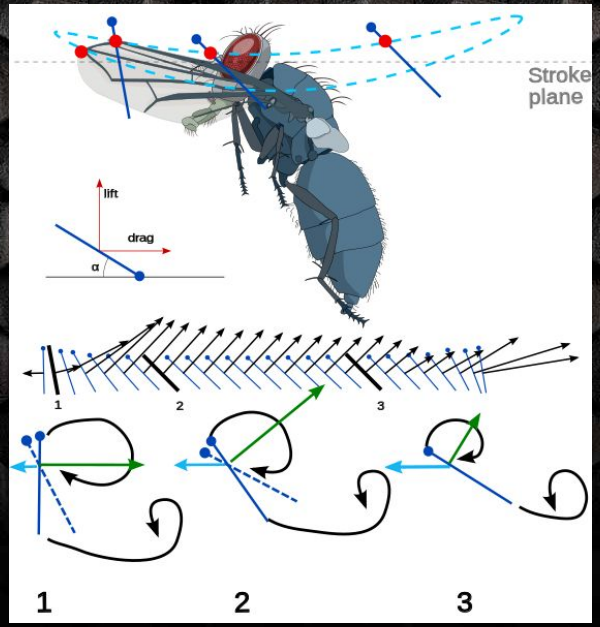
Animals that use powered flight

Insects

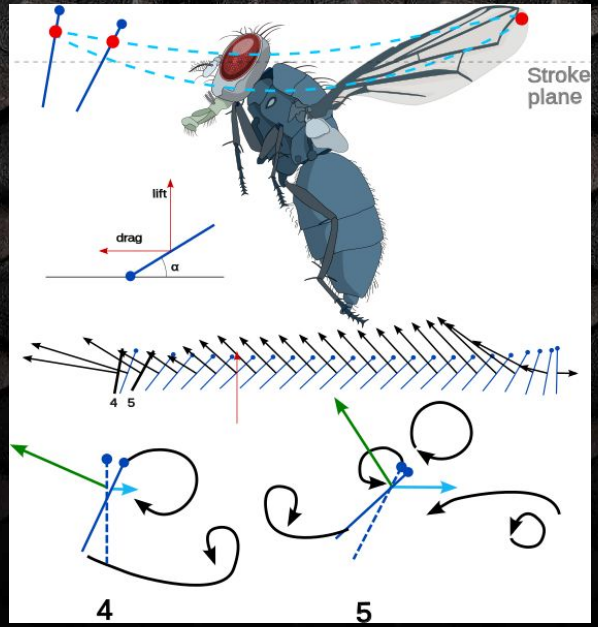
- First to evolve powered flight
- The mesothorax and metathorax may each have a pair of wings
- Wing structure
  - Outgrowths of the exoskeleton
  - Strengthened by longitudinal veins
  - Directly or indirectly moved by flight muscles
- Aerodynamic models
  - Leading edge vortex
  - Clap and fling



Leading Edge Vortex

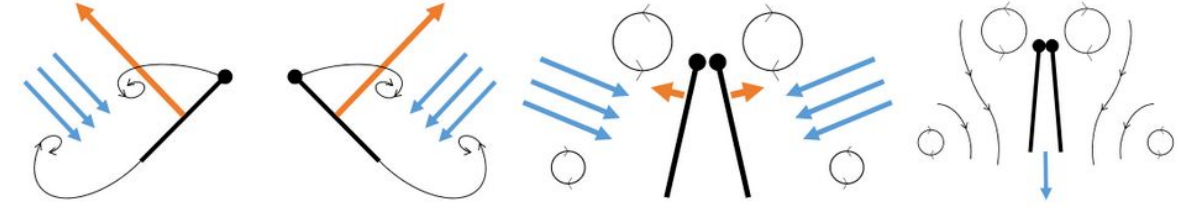


Downstroke



Upstroke

Clap and Fling



Clap and fling flight mechanism after Sane 2003

Clap 1: wings close over back

Clap 2: leading edges touch, wing rotates around leading edge, vortices form

Clap 3: trailing edges close, vortices shed, wings close giving thrust

Black (curved) arrows: flow; Blue arrows: induced velocity; Orange arrows: net force on wing

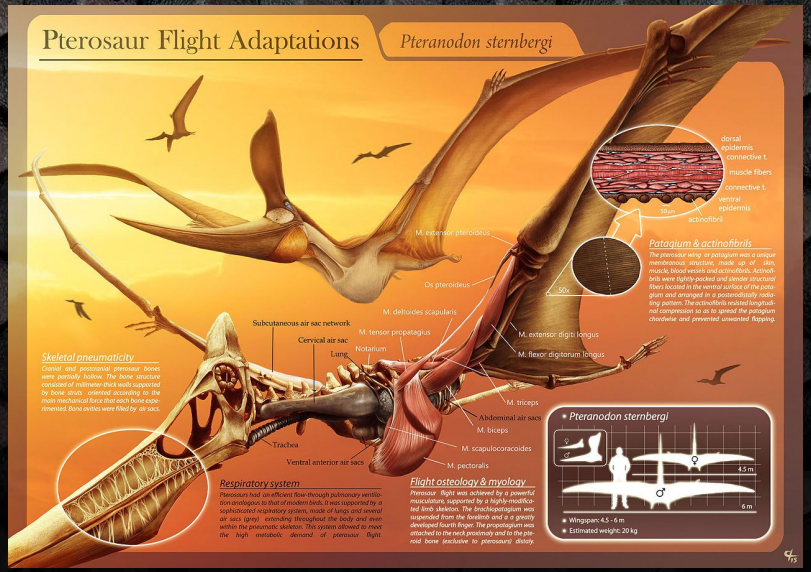
Fling 1: wings rotate around trailing edge to fling apart

Fling 2: leading edge moves away, air rushes in, increasing lift

Fling 3: new vortex forms at leading edge, trailing edge vortices cancel each other, perhaps helping flow to grow faster (Weis-Fogh 1973)

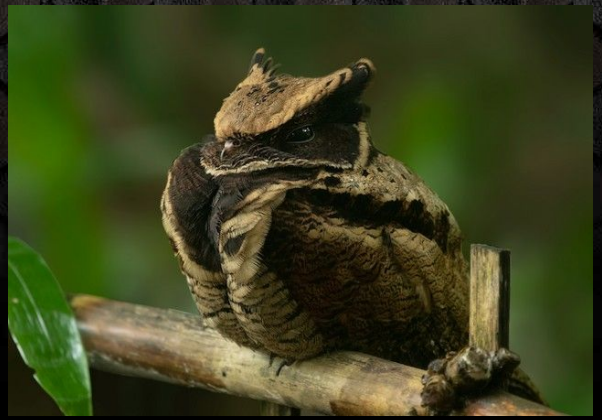
Pterosaurs

- Second to evolve flight
- Wing structure
  - Formed by bones and membranes of skin and other tissues
  - Attached to long fourth finger of each arm and the ankles
  - Strengthened by closely spaced fibers
- Hollow, air-filled bones
- Flight
  - Powerful muscles
  - Used a vaulting mechanism to obtain flight



Birds

- Third to evolve flight
- Types of flight
  - Gliding
  - Flapping
  - Bounding
  - Hovering
- Takeoff
  - Small birds jump upward to get lift
  - Large birds take a running start, facing into the wind, or dropping off a branch or ledge



Bird Flight

Gliding

- No propulsion
- Lift from potential energy or air currents

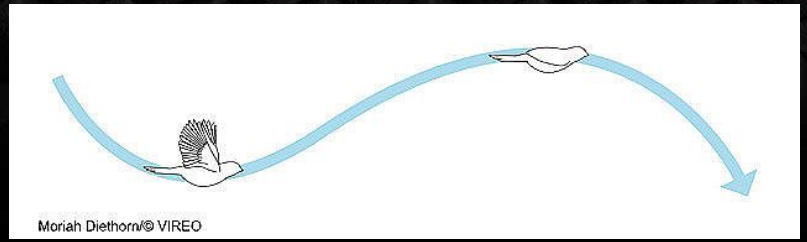
Flapping

- Uses wings to get lift and thrust
- Downstroke provides most of the thrust
- Upstroke provides some thrust

Bird Flight

Bounding

- Short bursts of flapping alternated with intervals in which the wings are folded against the body
- Reduces the aerodynamic drag when the wings are folded



Hovering

- True hovering generates lift through flapping alone
- Hummingbird flight is different from other birds
  - Wings are extended the whole stroke
  - Symmetrical figure eight shape
  - Beats up to 80 times per second

Bats

- Fourth to evolve flight
- Only mammal capable of true flight
- Evolved flight 52.5 million years ago
- Evolution
  - Patagium, abdomen skin running to the tip of each digit
  - Thinner cortical bone to reduce torsional stresses from propulsive downstroke movements
  - Rerouted innervation to their wing muscles for control of powered flight
  - Increased strength and mass of forelimb musculature for powerful upstrokes and downstrokes
  - Metabolic adaptations for the increased energy cost of flight

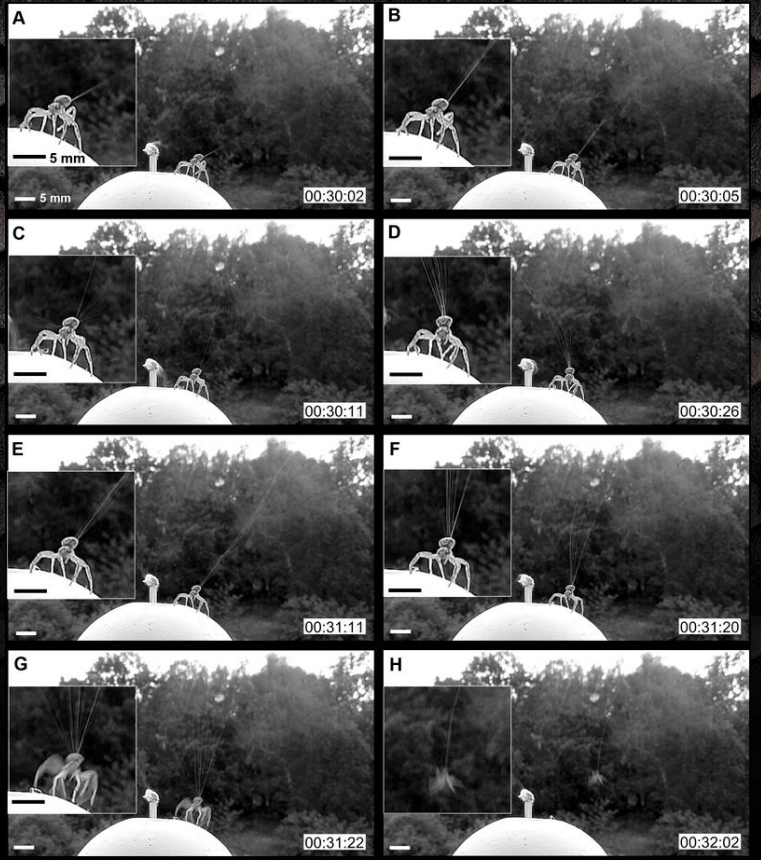
“You see the animal lift its wings in a dramatic fashion, and it goes and it lifts off the ground. That's not how things take off. Flapping starts after takeoff. Flapping doesn't cause takeoff”

- Stuart Sumida, a vertebrate paleontologist

Externally powered flight methods

Ballooning

- Used by spiders and other small Invertebrates
- Flies by releasing gossamer thread(s) into the air
- Source of lift
  - Air currents
  - Electric fields



Soaring

- Requires a structure that can catch air
- Source of lift
  - Rising air from thermals, ridge lift, or other meteorological features
  - Moving air
- Wandering albatross
  - Largest wingspan of birds today, up to 11.5 ft
  - Can soar for several hours without flying
  - Can use less energy in the air than while sitting

Magic

- Magic can make things fly

Dragons

“Truly impossible hybridization event between insects, dinosaurs, and bats.”

- David A. Duchêne, evolutionary biologist at the University of Copenhagen

Are you a dragon?

No.