




Senses & Cognition

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Birds are visual organisms

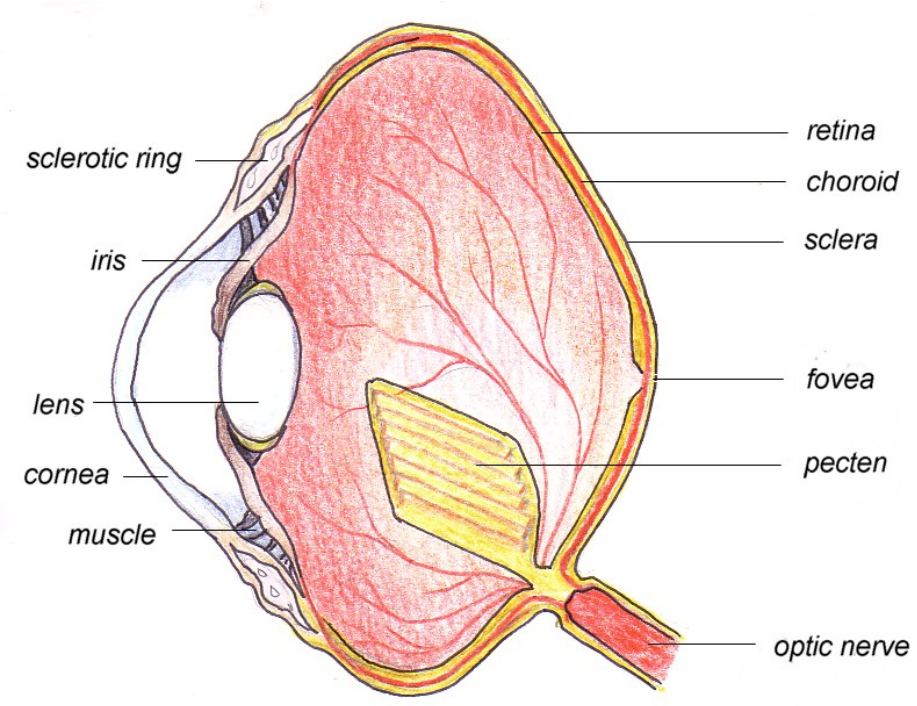
- Vision deeply important to feeding, reproduction, avoiding predators
- Bird eyes are large (human-sized in some eagles and owls) and sophisticated
- Songbirds and raptors can resolve details 2-3x farther than us



Paradisornis rudolphi

Bird eye anatomy

- both **lens** and **cornea** change shape to focus
- focus via **Campton's** & **Brucke's** muscles on **sclerotic ring**
- **pecten** structure enhances blood supply without constraining receptor density
- **fovea** a pit of high cone density for sharp central vision



Wikipedia

External eye features

- **nictating membrane** (L): shared with other reptiles; transparent membrane that moves front to back to moisten and protext eyes (particularly diving birds)
- **tapetum lucidum** (R): "eyeshine" of night birds caused by lipid spheres in retina that scatter light to improve vision; physiological, not permanent





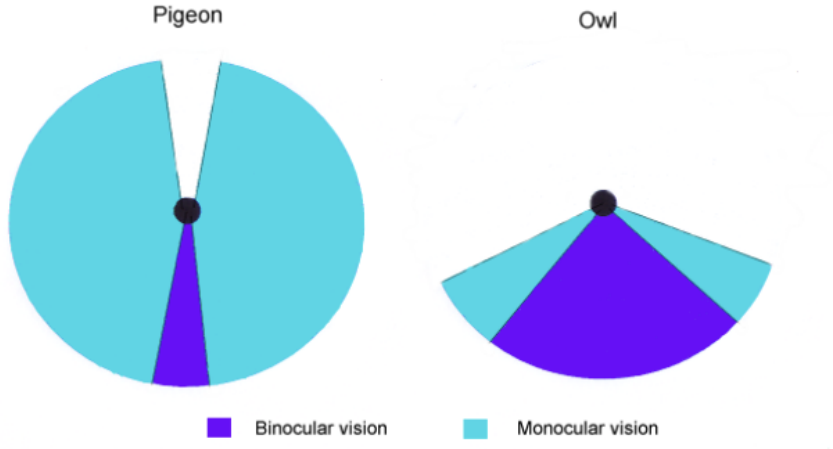
Audubon; Maryland Biodiversity Project

Eye position impacts field of vision

- **binocular vision**: better depth perceptinon
- **monocular vision**: can enhance field of view; head bobbing or switching angles to compensate for reduced depth perception

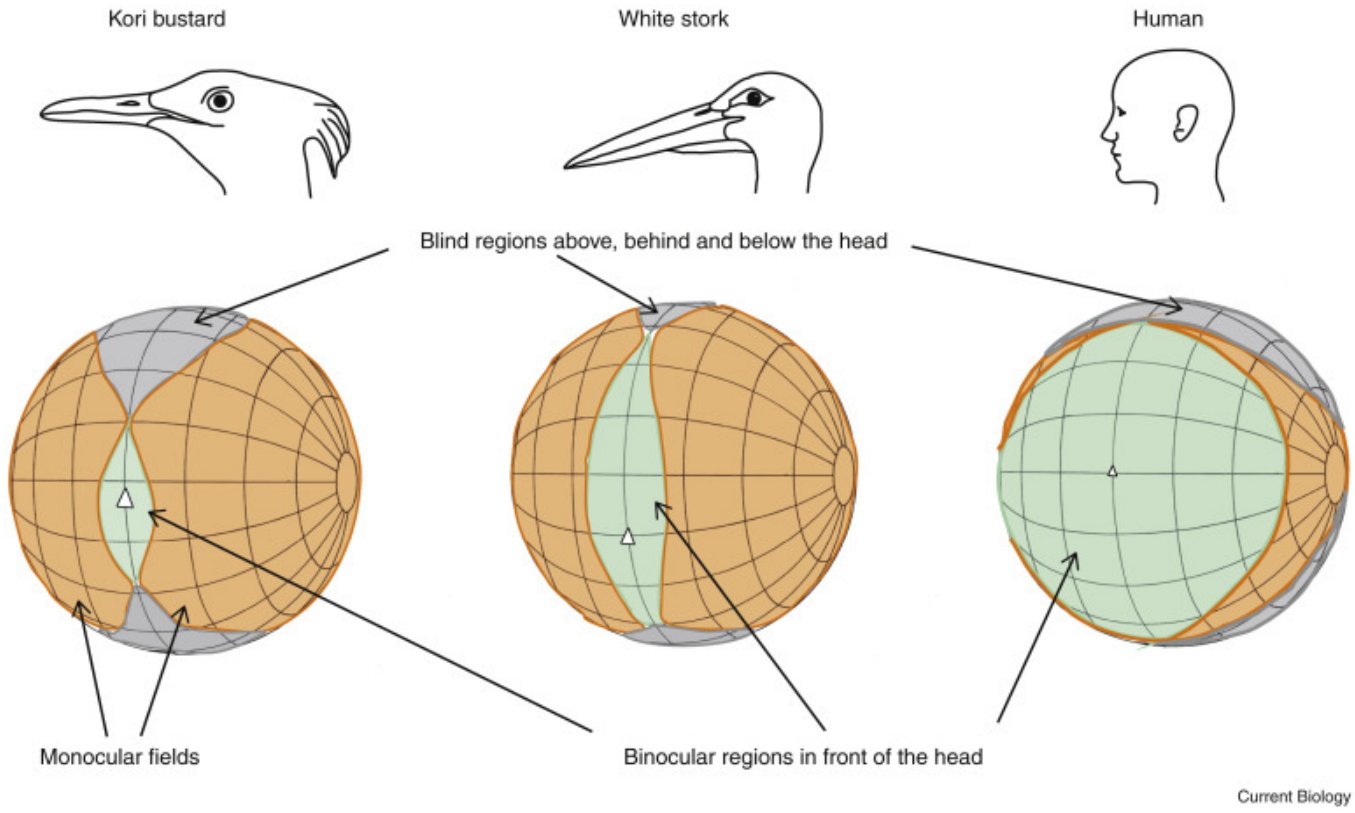






Columba livia; *Bubo virginianus*; Wikipedia

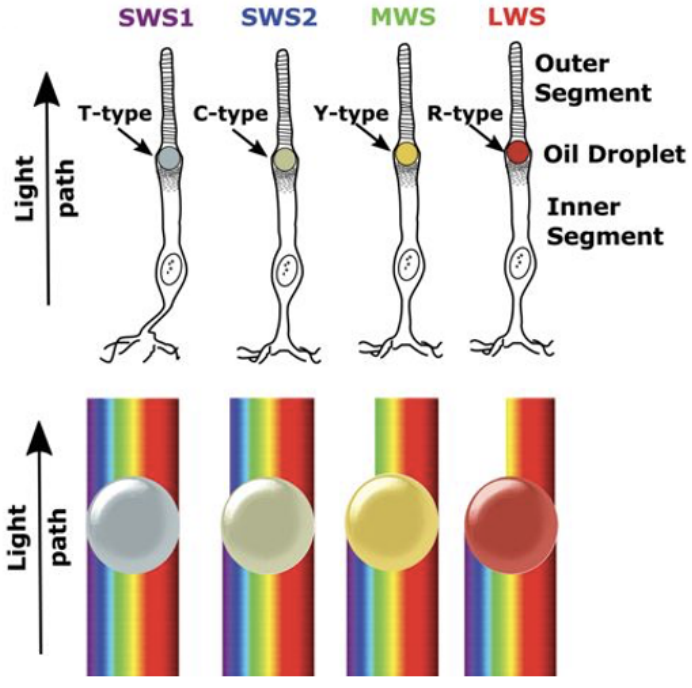
Eye position impacts field of vision

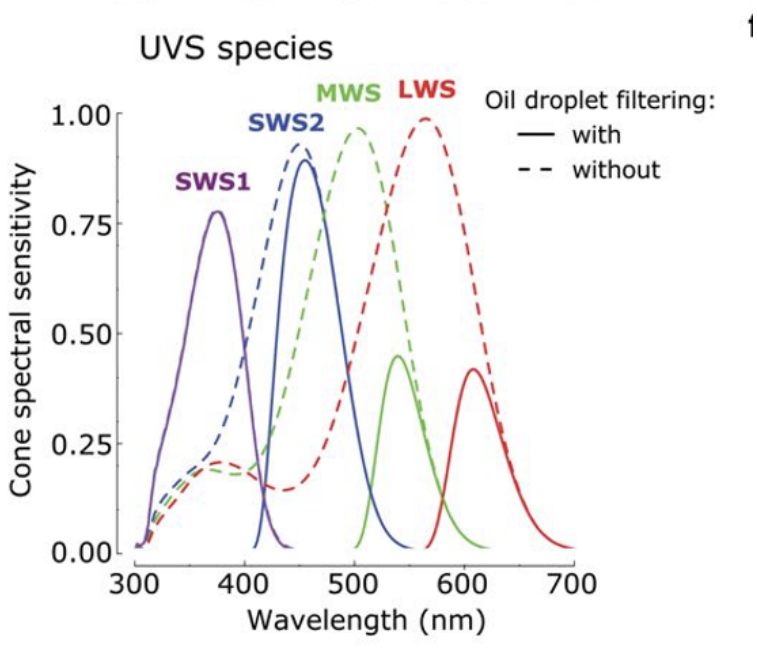


(Martin 2022)

Light sensors

- **rods** are highly sensitive receptors for low light
- **cones** are coiled proteins containing carotenoid pigment; sensitive to different portions of the visible spectrum
- **oil droplets** reduce light but enhance color discrimination

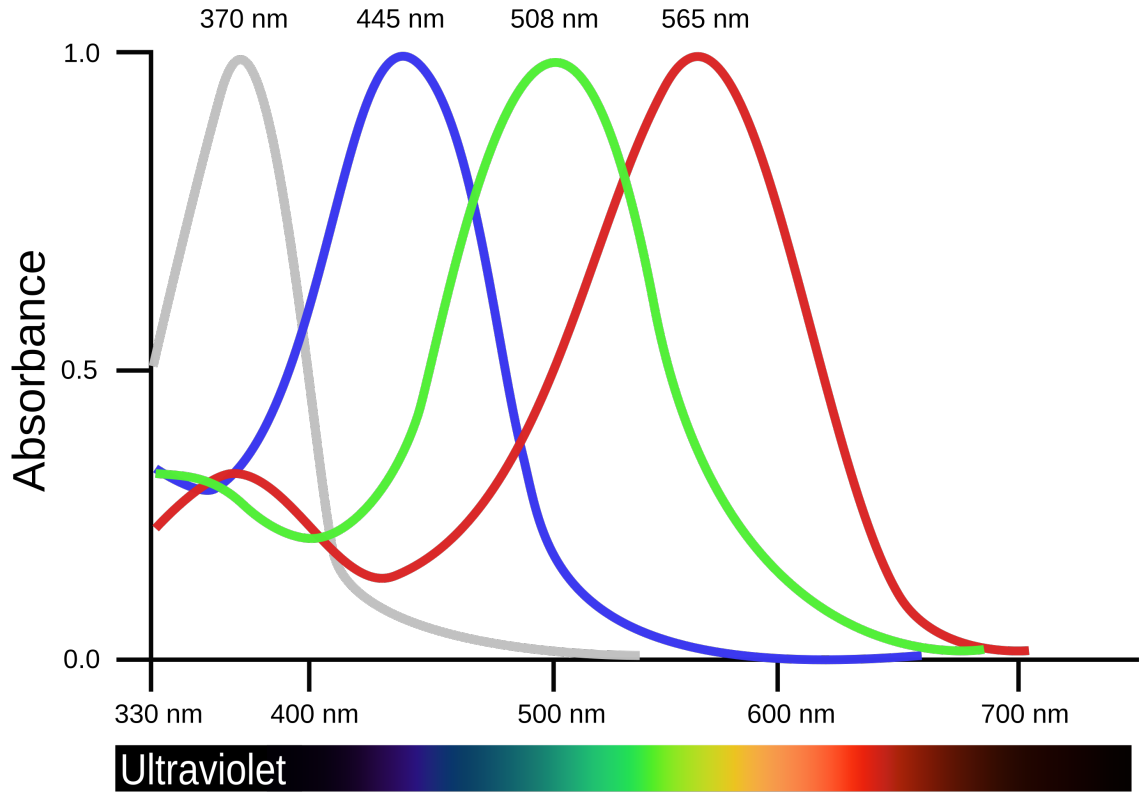




(Toomey et al. 2016)

Birds perceive ultraviolet light

- Birds can see light from 325 to 700 nanometers (versus 400 to 700 in humans)
- Cone types for red, green, blue, and ultraviolet light (versus just RGB in humans)



(Wikipedia)

What explains this Mountain Bluebird's coloration?

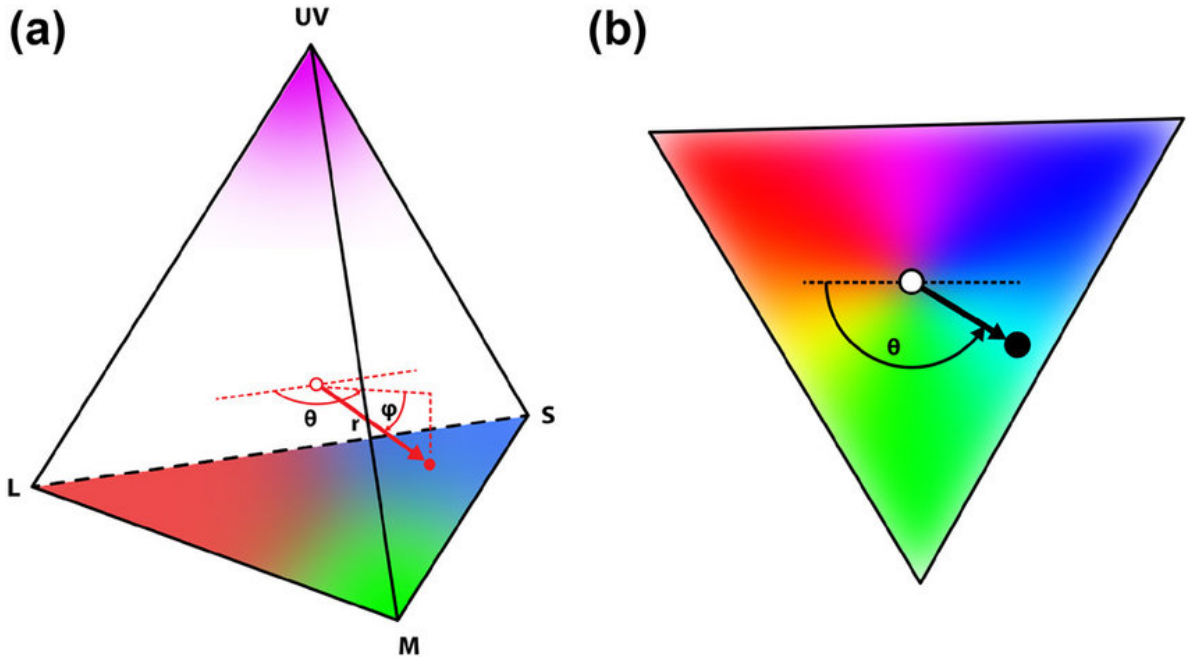


Sialia currucoides

a) light from approximately 400 to 500nm is being absorbed by structural features
b) light from approximately 400 to 500nm is being absorbed by pigment
c) light from approximately 400 to 500nm is being reflected by structural features
d) light from approximately 400 to 500nm is being reflected by pigment

Tetrahedral color space

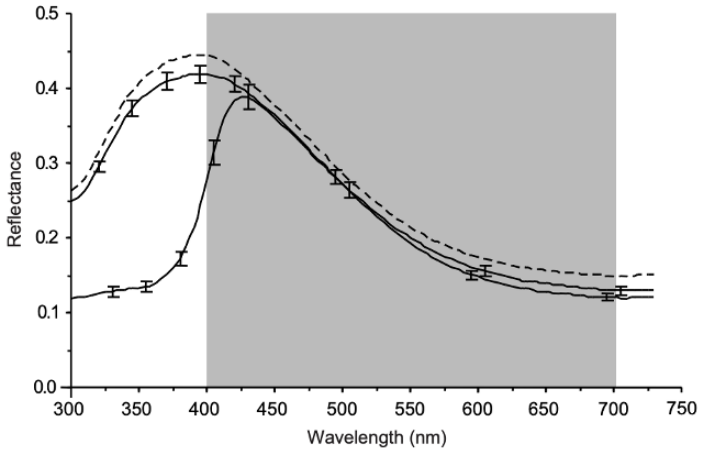
- Combinations of cones create 2D color space in humans (b), 3D color space in birds (a)
- Color comprised of **hue** (angle from center of color vector) and saturation (distance from center)
- Vertical axis of avian color tetrahedron defines colors that are unperceivable and unimaginable to humans



(Janas et al. 2019)

UV colors impact reproduction

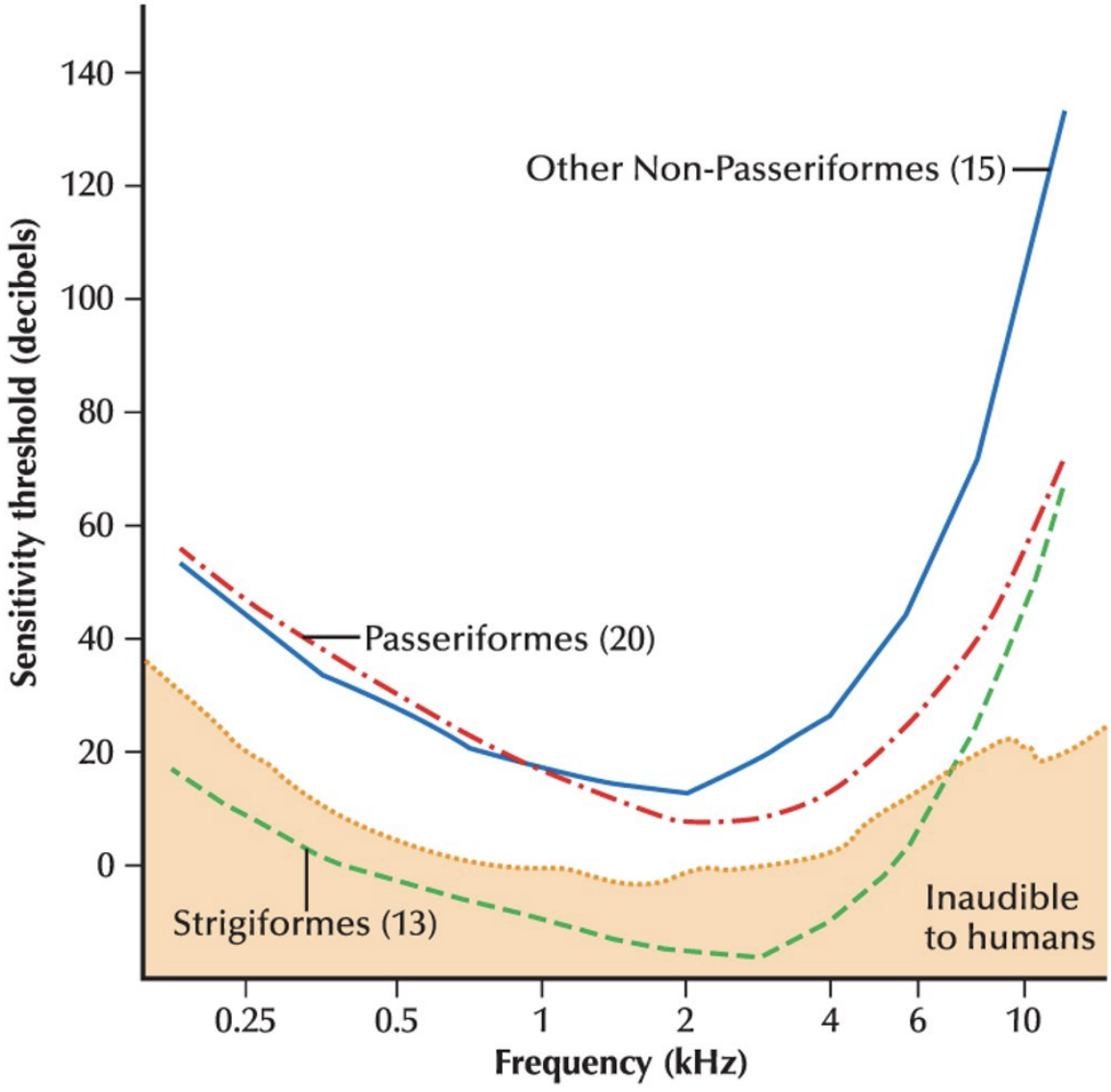
- Male Bluethroats (*Luscinia svecica*) were left untreated (top), rubbed with baby oil (middle), or rubbed with sunblock (bottom)
- Birds treated with sunblock had lower mating success





(ML182455611; Johnsen et al. 1998)

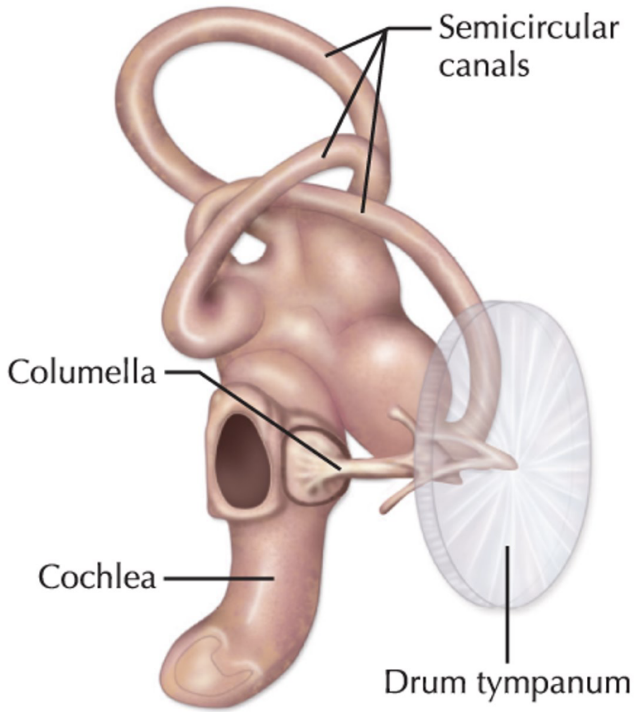
Bird hearing is not extraordinary



(Gill et al. 2019)

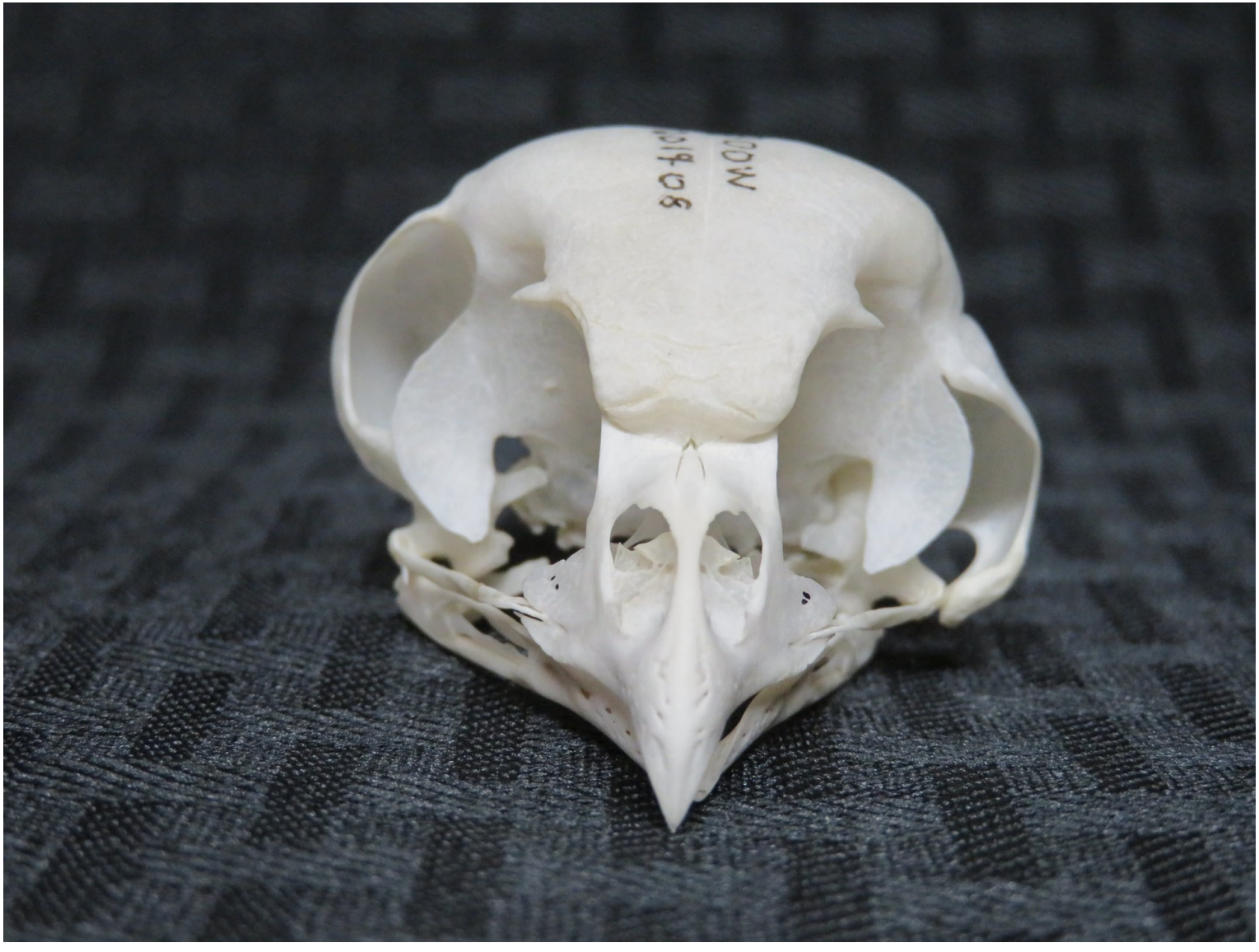
Bird ear anatomy

- no external ear (**pinnae** of mammals); instead, an **ear funnel** covered with feathers
- the **stapes** (**columella**) transmits sound vibrations to the **tympanum**
- the **semicircular canals** control balance
- the **cochlea** is the inner ear



(Gill et al. 2019)

Asymmetrical ears aid prey location



(*Aegolius funereus*, International Owl Center)

Echolocation

- known in swiftlets (*Aerodromus* and *Collocalia*) and oilbirds (*Steatornis*)

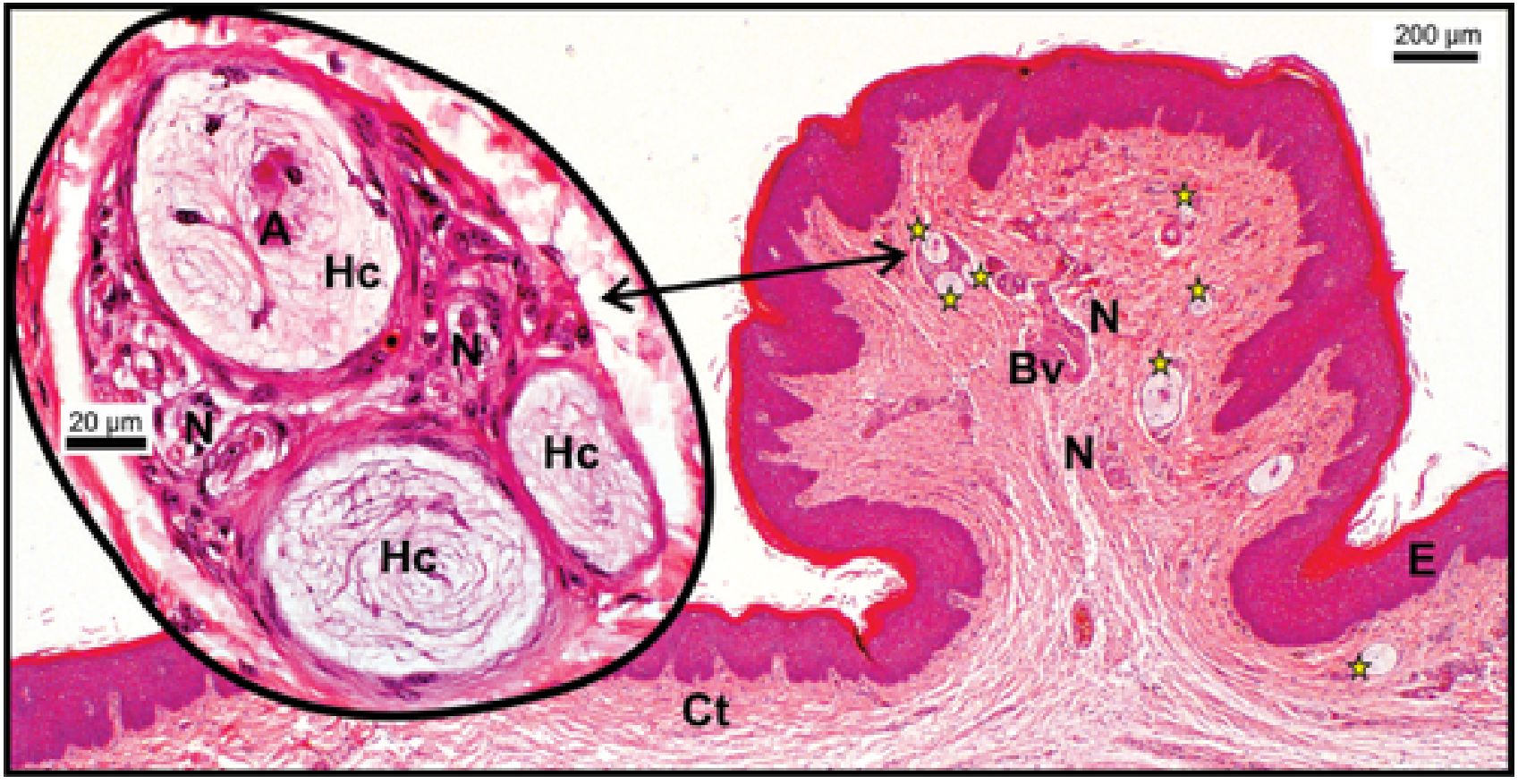


https://www.youtube.com/watch?v=lKEYMJ1vjj8

Steatornis caripensis

Tactile sensation

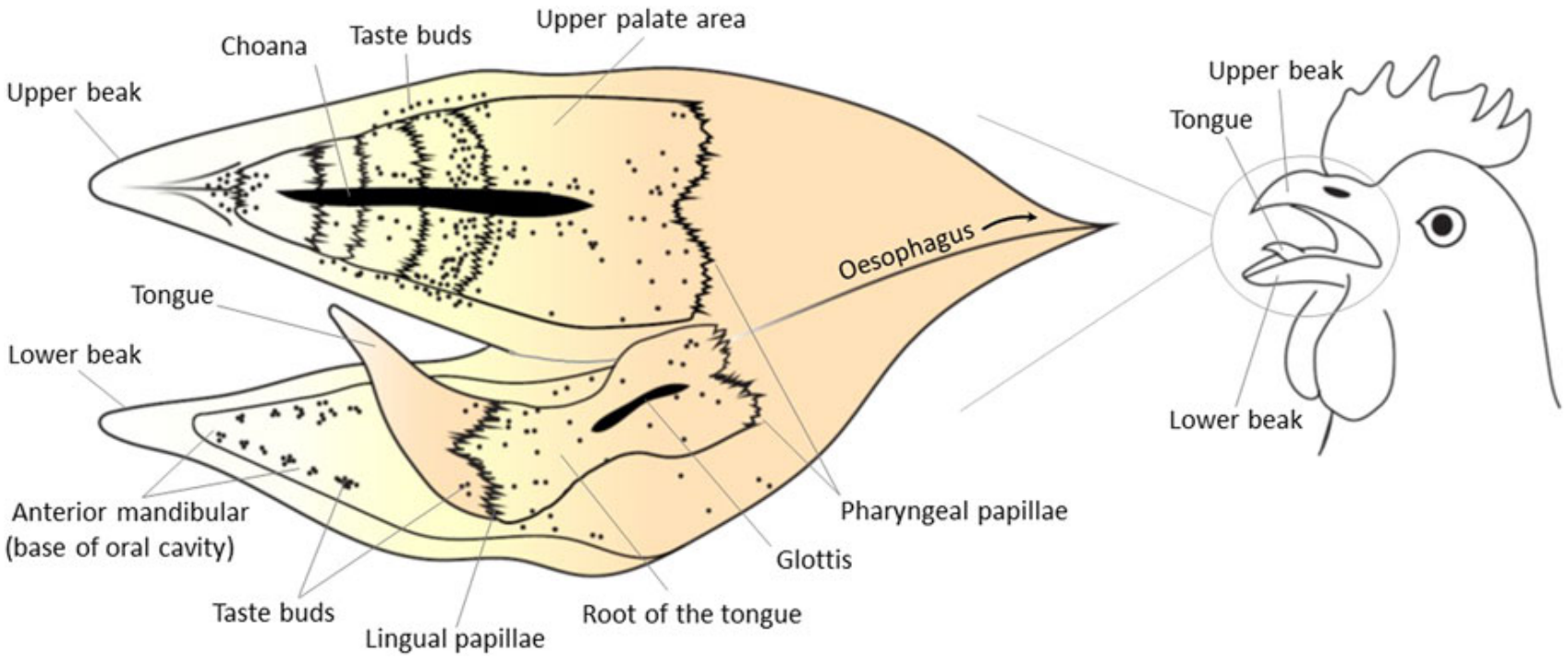
- **Hebst corpuscles**: largest and most common touch receptors
- Merkel corpuscles: skin, bill, tongue
- Gandry corpuscles: in duck bills only



(Crole & Soley 2014)

Birds have a poorly developed sense of taste

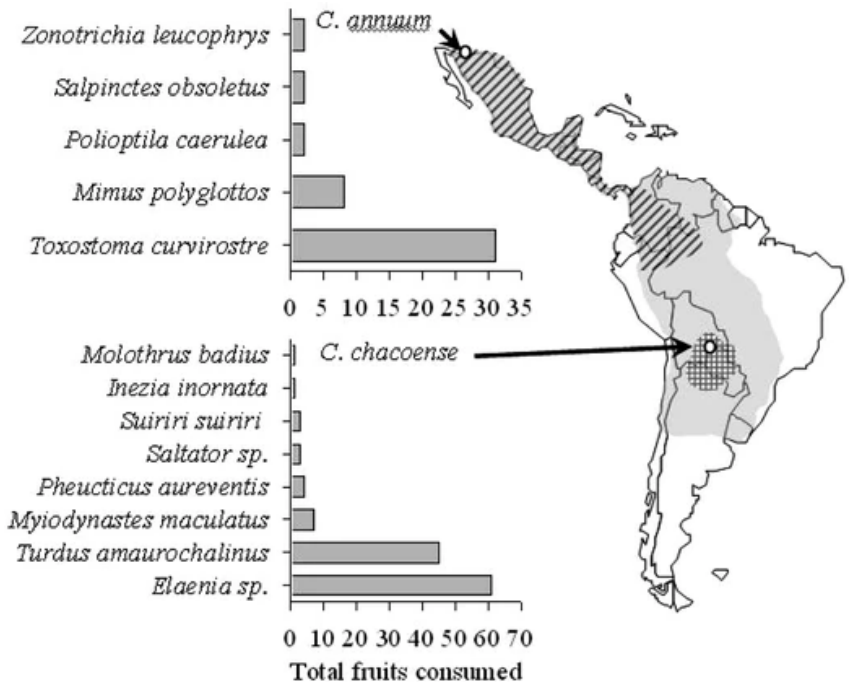
- 2 (chicken) to 62 (Japanese Quail) taste buds on rear of tongue and back of throat versus 10,000+ on tongue in humans



(Crole & Soley 2014)

Birds are not sensitive to capsaicin

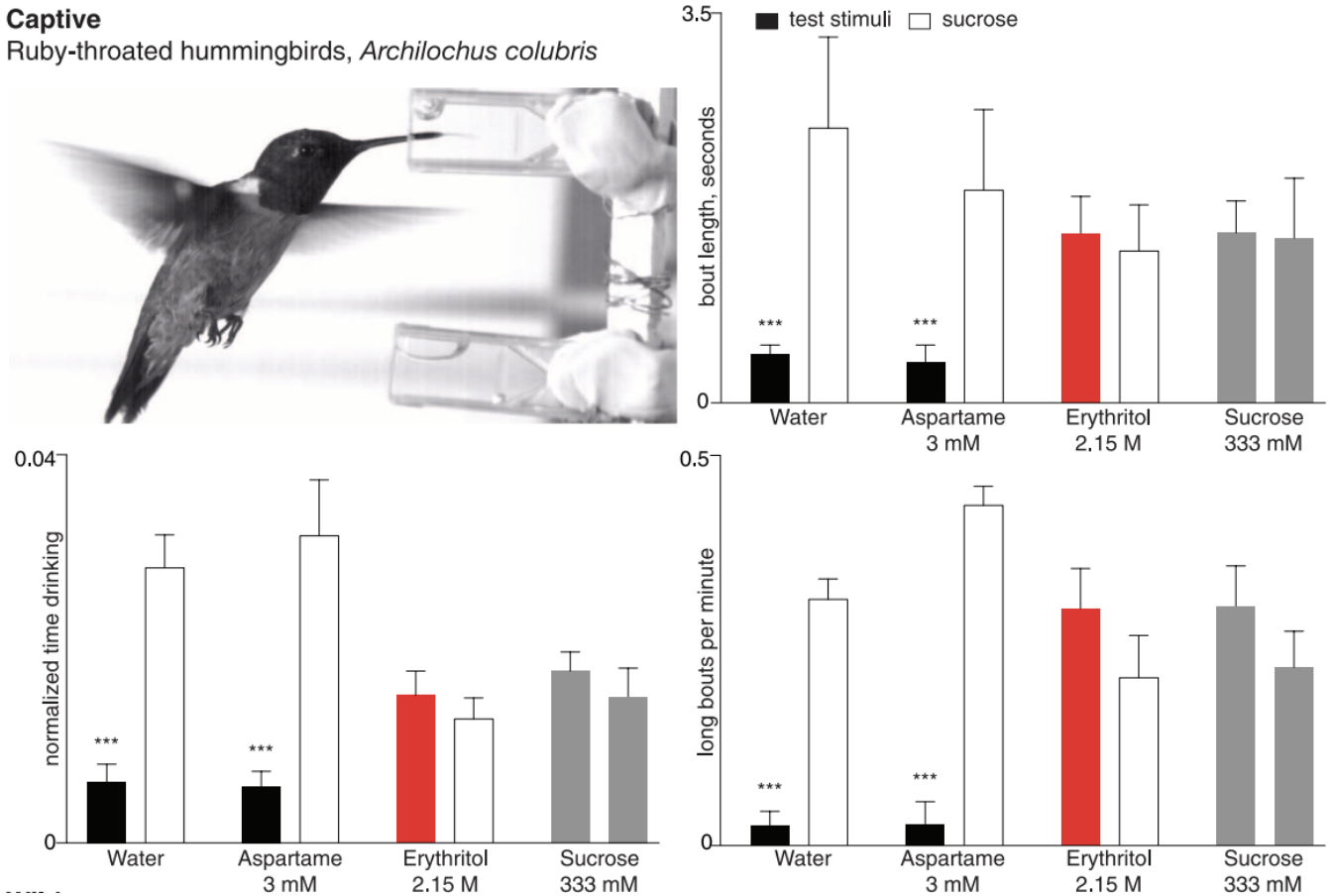
- **directed deterrence hypothesis**: secondary metabolites in ripe fruit function to deter fruit consumption by vertebrates that do not disperse seeds, while not impacting consumption by those that do
- Levey et al.: NO chili consumption by rodents in AZ / Bolivia, even though shown in lab; entirely by birds



(Levey et al. 2006)

Hummingbirds can taste sugar

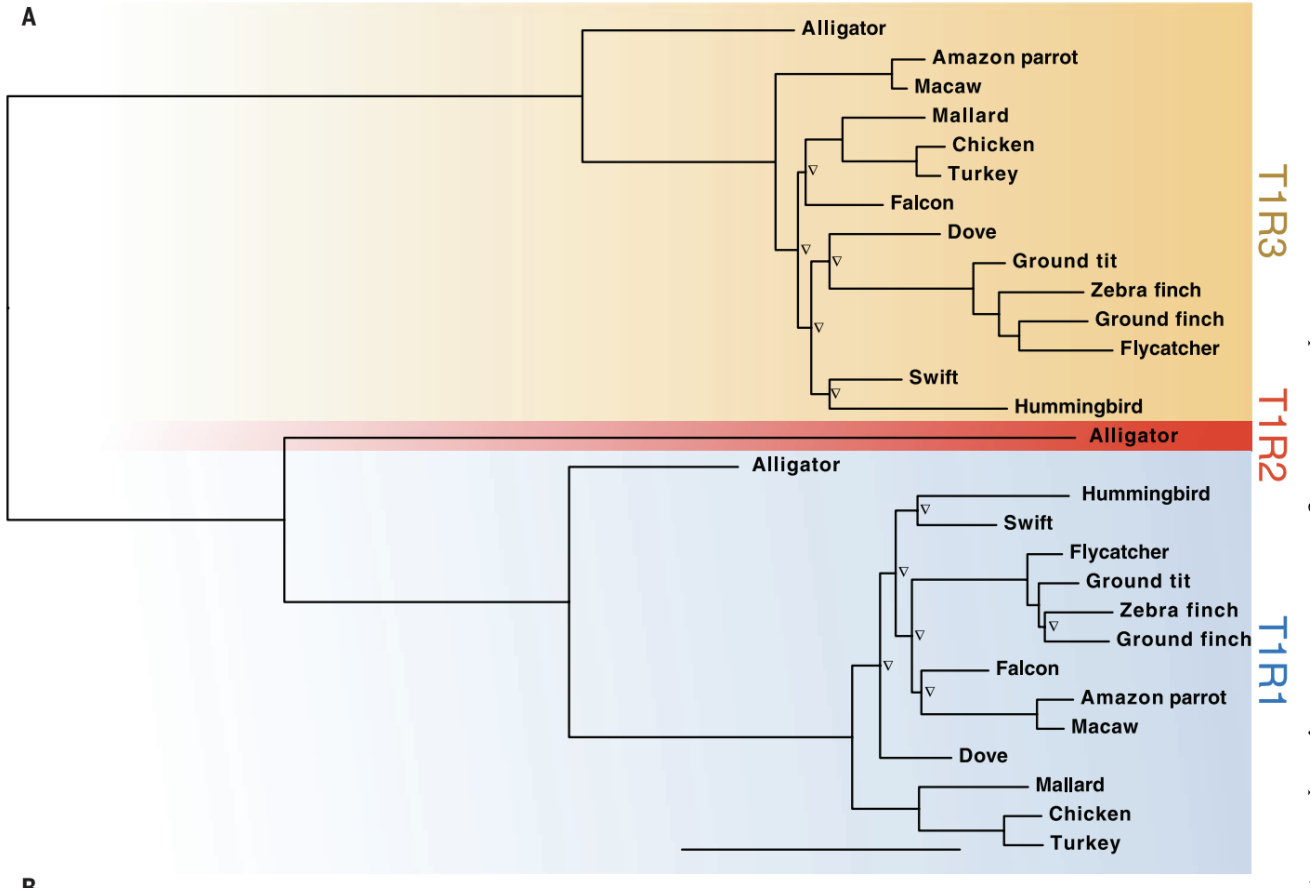
- strong feeding preference for sucrose and erythritol, which activate T1R1-T1R3 sensors
- limited time feeding on water or aspartame, which fail to activate T1R1-T1R3 sensors



(Baldwin et al. 2014)

Sweet receptor a novel modification of umami T1R3 protein

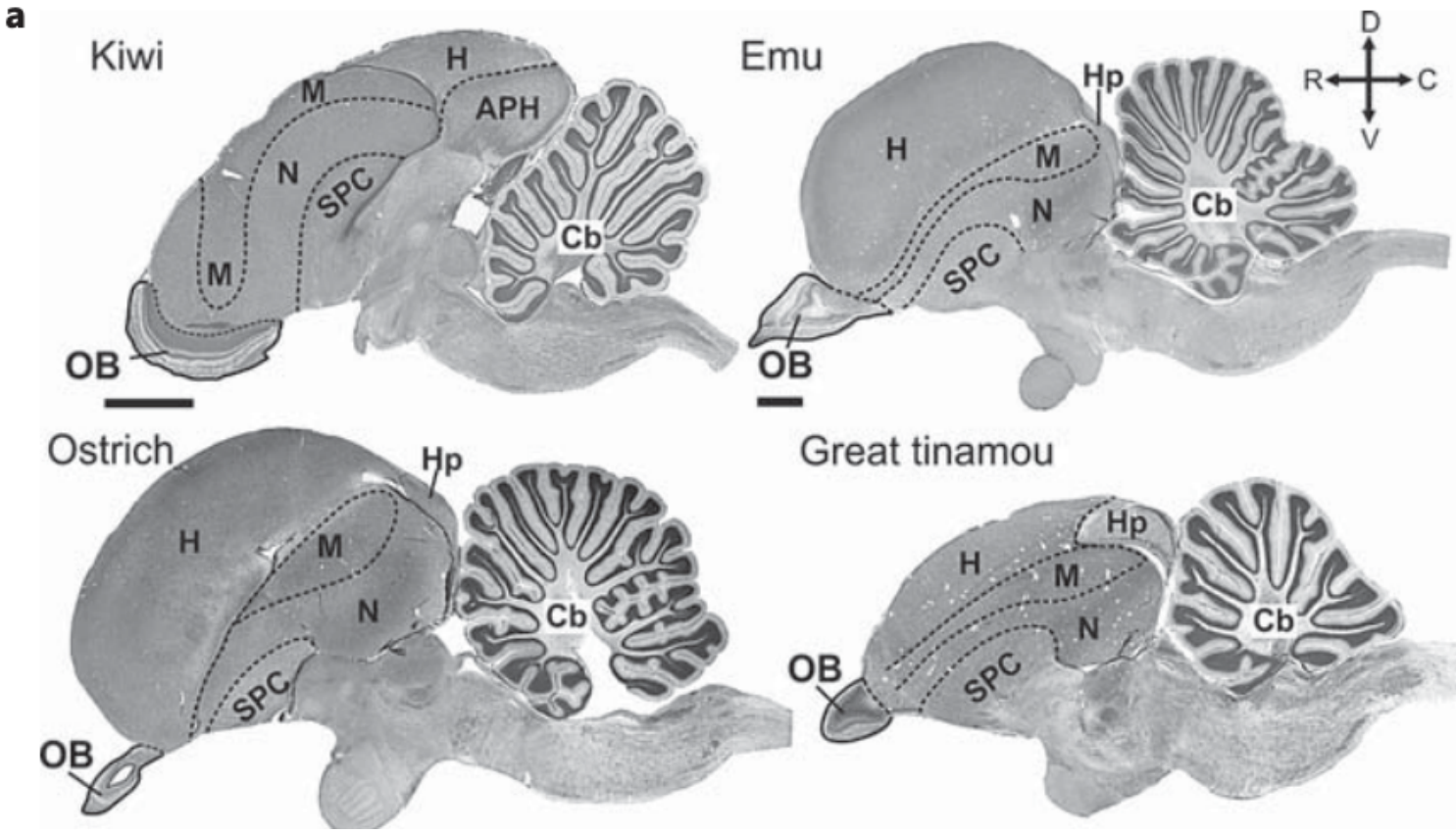
- Most birds lack T1R2 sweet receptor
- Hummingbirds have modified TR13 protein that responds to carbohydrates



(Baldwin et al. 2014)

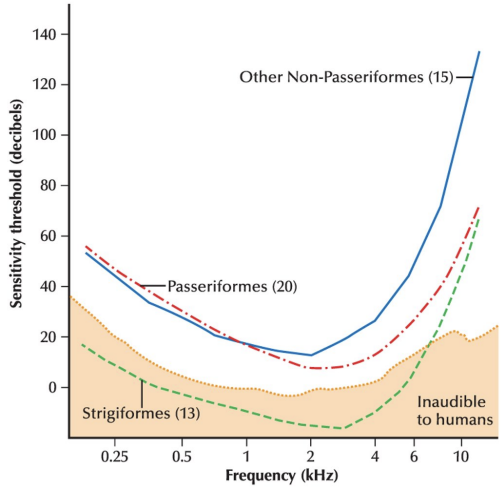
Enhanced olfactory bulb in Kiwi

- Olfactory bulb large in scent-dependent species: kiwis, vultures, petrels



(Baldwin et al. 2014)

Which of the following features is related to hearing?

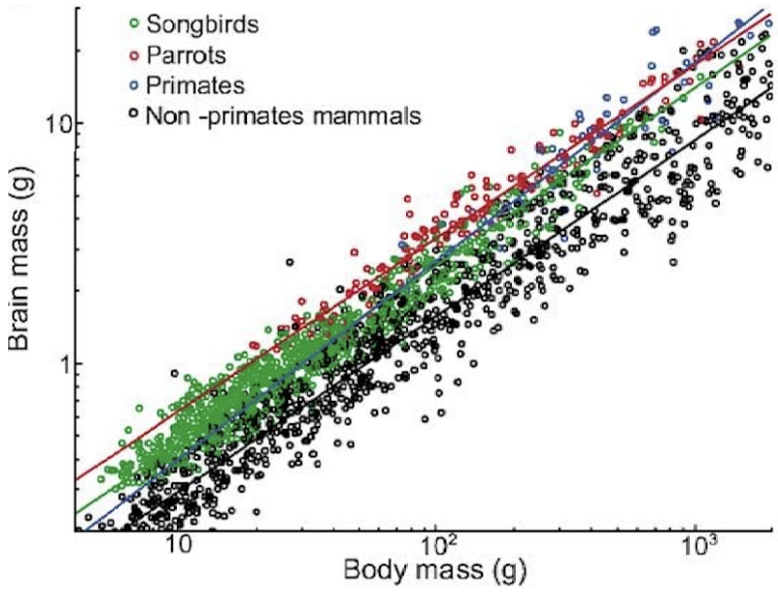


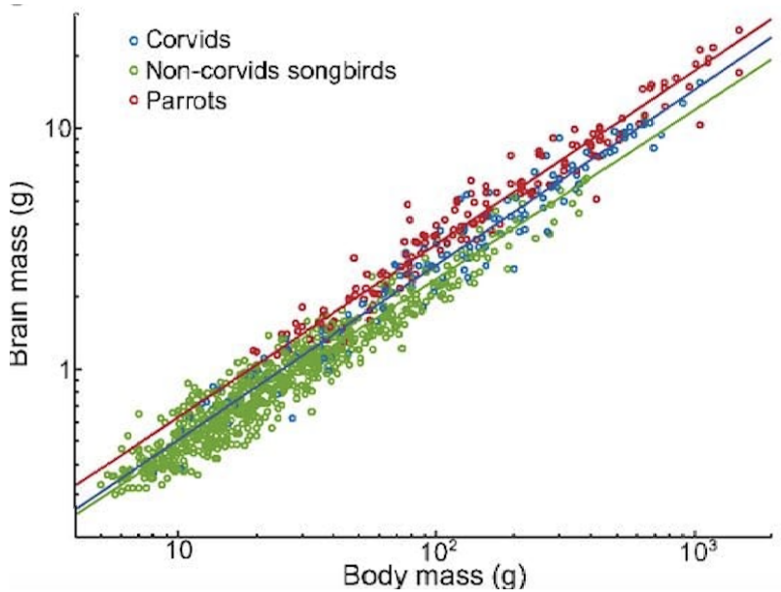
(Gill et al. 2019)

a) nictating membrane
b) Hebst corpuscule
c) Gandry corpuscule
d) stapes
e) olfactory bulb
f) fovea

Birds can be very intelligent

- Brain large relative to body size, particularly in songbirds and parrots
- The smartest species show object permanence, can delay gratification, remember past episodes and plan ahead, reason to solve puzzles, recognize themselves in the mirror, infer mental states of others, show awareness of own learning (metacognition), learn complex songs

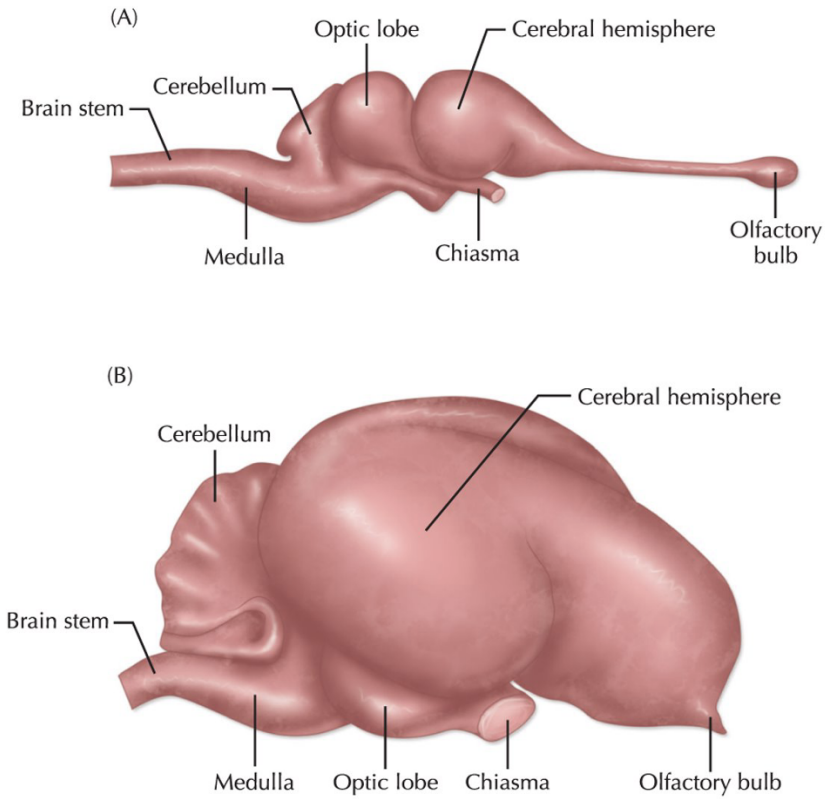




(Olkowicz et al. 2016)

Bird brain anatomy

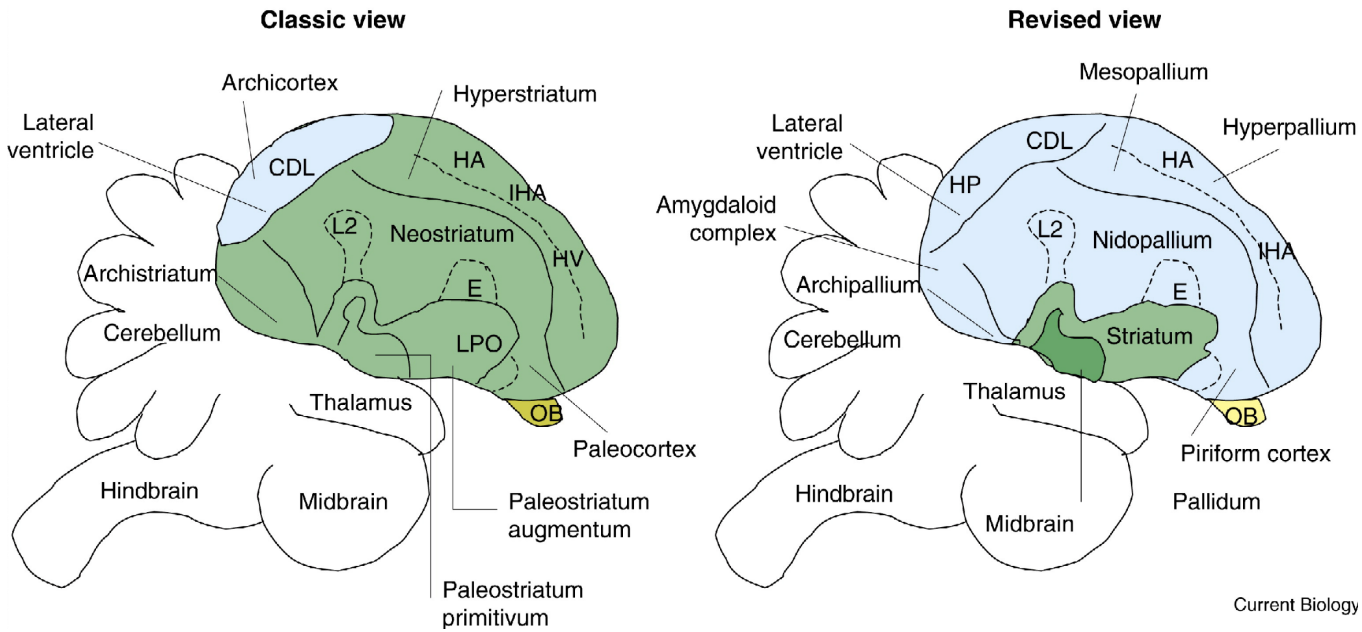
- **forebrain**: instinctual behaviors, learning, sensory integration
- **midbrain**: vision, coordination, physiology, hormones
- **hindbrain / medulla**: links to spinal cord and peripheral nervous system



(Gill et al. 2019)

An evolving view of the avian forebrain

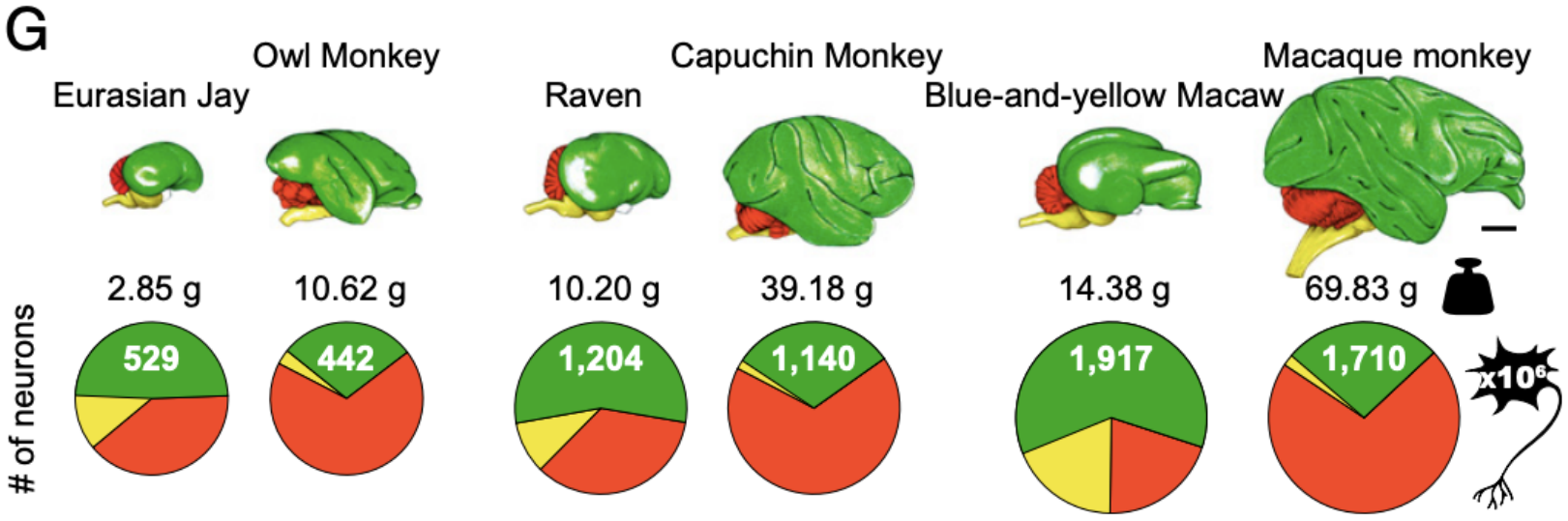
- Majority of avian forebrain long thought to be homologous with mammalian **striatum** (involved in instinctive behavior)
- More recently discovered to consist of **pallial** elements associated with learning and intelligence



(Emery 2007)

Birds have high neuronal density

- Corvids and parrots have more pallial neurons in forebrains than primates 3x as large!

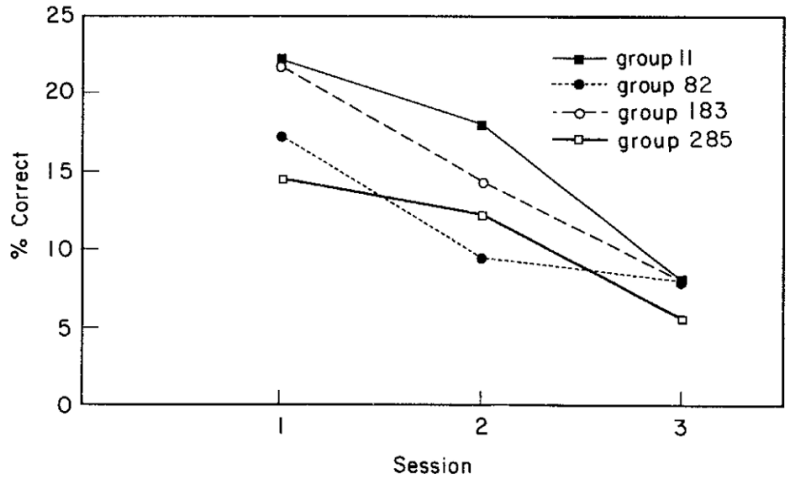


(Olkowicz et al. 2016)

Seed caching in Clark's Nutcrackers

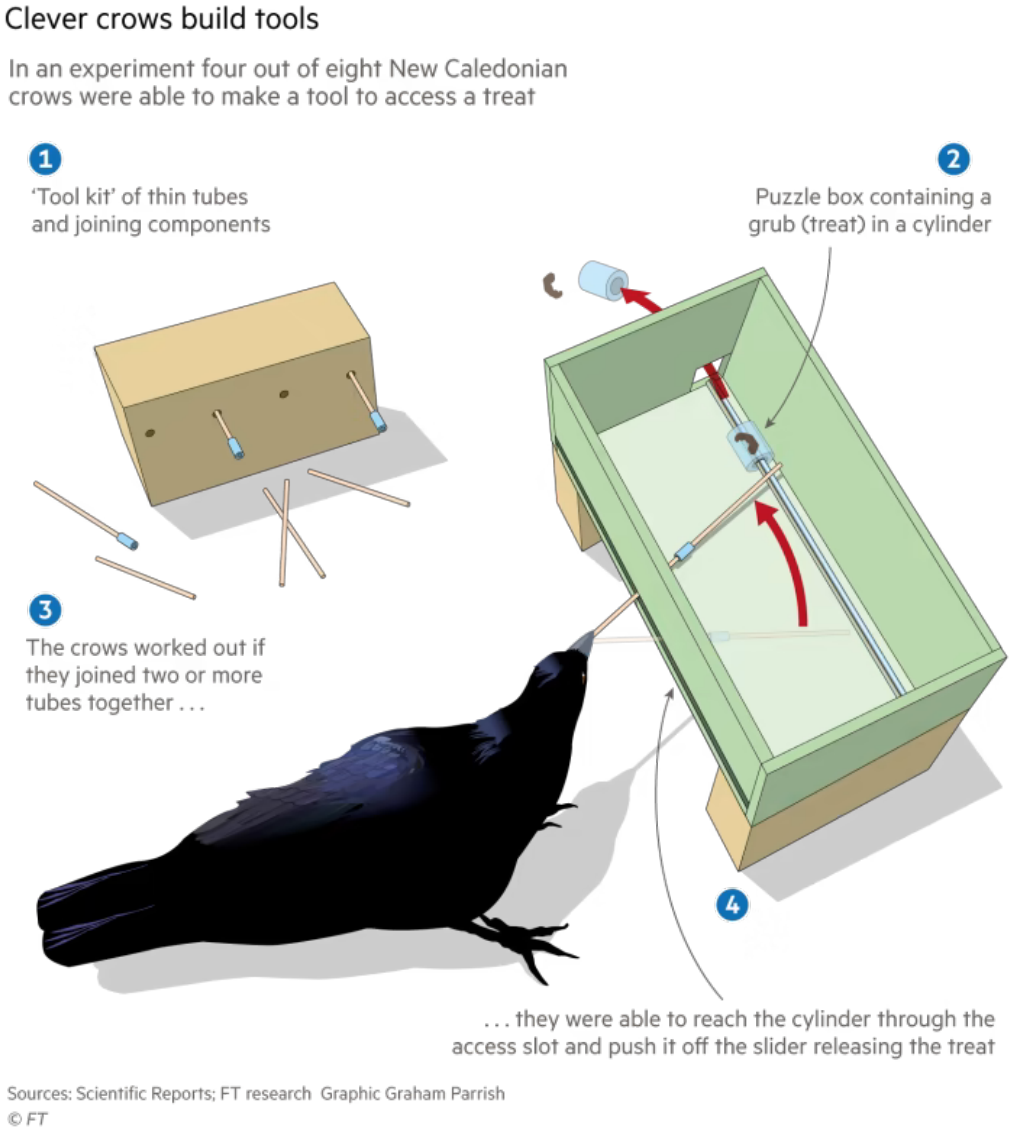
- Seed caching behavior requires impressive cognitive ability (especially spatial memory)
- Experiments show Clark's Nutcrackers recover stashed seeds at a higher rate than random expectations (but this decays over time)





Nucifraga columbiana; Balda & Kamil 1992

New Caledonian crow tool use



https://www.youtube.com/watch?v=EryZPmOxwC0&t=15s

(Bayern et al. 2018; Minerva)

Keas understand probability



https://www.youtube.com/watch?v=Yj718A7_s4A

Nestor notabilis

Alex the Parrot

Alex (parrot)

28 languages

Article Talk Read Edit View history Tools

From Wikipedia, the free encyclopedia

Alex (May 18, 1976 – September 6, 2007)[1] was a grey parrot and the subject of a thirty-year experiment by animal psychologist Irene Pepperberg, initially at the University of Arizona and later at Harvard University and Brandeis University. When Alex was about one year old, Pepperberg bought him at a pet shop.[2] In her book *Alex & Me*, Pepperberg describes her unique relationship with Alex and how Alex helped her understand animal minds.[3] Alex was an acronym for avian language experiment,[4] or avian learning experiment.[5]

Before Pepperberg's work with Alex, it was widely believed in the scientific community that a large primate brain was needed to handle complex problems related to language and understanding; birds were not considered to be intelligent, as their only

Alex



Alex participating in a numerical cognition experiment

Species	Grey parrot (*Psittacus erithacus*)
Sex	Male
Hatched	May 18, 1976 United Kingdom
Died	September 6, 2007 (aged 31) Brandeis University, Waltham, Massachusetts, United States
Known for	Intelligent use of language
Owner	Irene Pepperberg

https://www.youtube.com/watch?v=ldYkFdu5FJk

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