

Levels of analysis and hypothesis testing



Western Hognose Snake playing dead

Identify the level of analysis for the following hypotheses. Use one of the following letters to identify the larger unit: P for proximate, U for ultimate, AND one of the following letters to identify the subunit: H for evolutionary history; O for ontogenetic; M for mechanistic; F for functional.

_____ Young white-crowned sparrows develop neural connections between the HVC and other song control nuclei as they crystallize their song.

_____ Birds don't fly when dead leaves blow around because flight from non-threatening objects wastes energy resources.

What questions are asked by people that study Animal Behavior?

Four levels of analysis in animal behavior

1. Mechanistic: physiological & cognitive & genetic expression(real-time)
 2. Ontogenetic: all development; including learning & changes in physiology& changes in genetic-expression(*development*)
 3. Fitness/Functional/Adaptive
 4. Evolutionary origins/history
- proximate**
- ultimate/
evolutionary**



Understanding proximate & ultimate explanations/hypotheses: bird song

- Well-studied model for understanding relationships between...
 - Brain anatomy (neurobiology)
 - Genetics of development
 - Behavioral development and learning
 - Role of song in competition and attraction of mates



study 1:
two competing hypotheses
(hypotheses are within one level of analysis)

Observation: Only few groups of birds learn to sing (most birds have innate song)

Observation: Only few groups of birds learn to sing (most birds have innate song)

HOW do phoebes acquire their song:
1) through learning or 2) innate?



Eastern Phoebe

Observation: Only few groups of birds learn to sing (most birds have innate song)

**HOW do phoebes acquire their song:
1) through learning or 2) innate?**



Eastern Phoebe

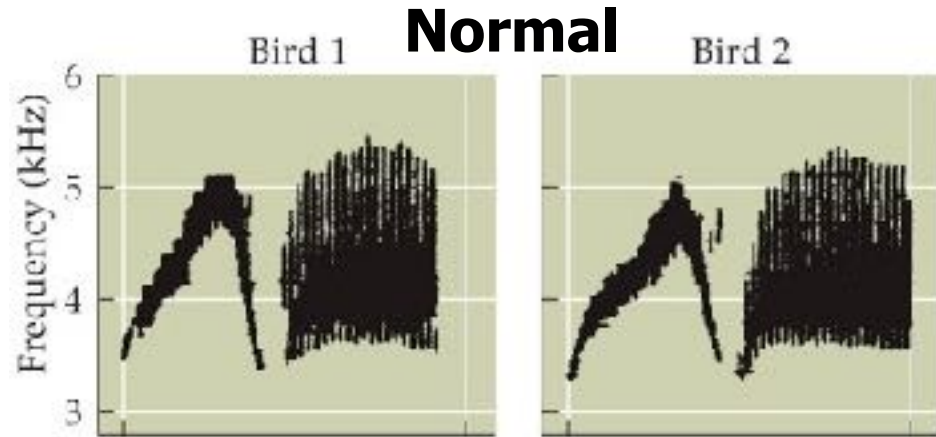
both are ontogenetic (developmental) hypotheses, so they can compete

Observation: Only few groups of birds learn to sing (most birds have innate song)

HOW do phoebes acquire their song:
1) through learning or 2) innate?



Eastern Phoebe

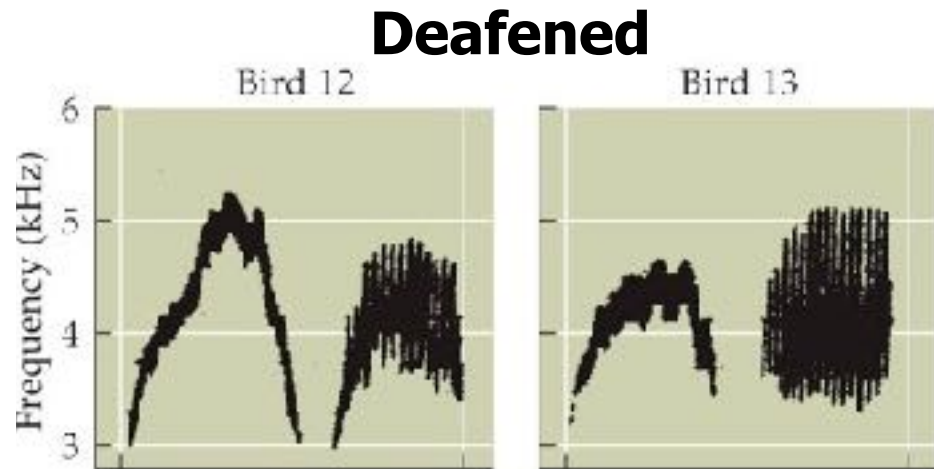
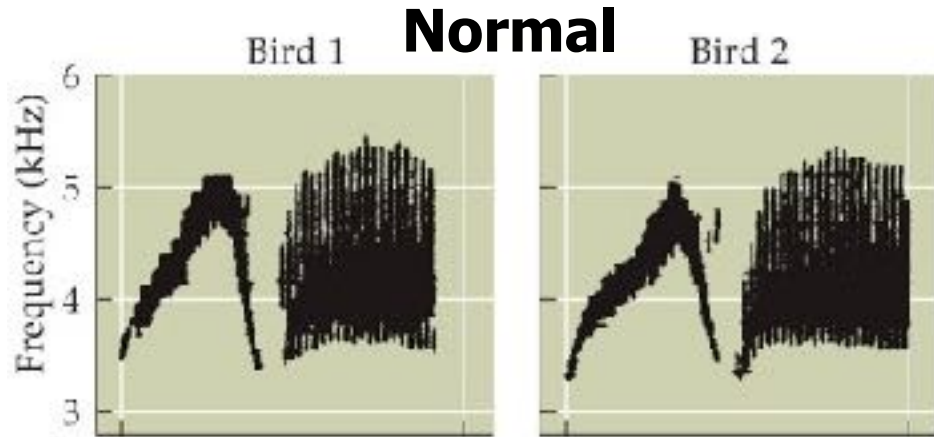


Observation: Only few groups of birds learn to sing (most birds have innate song)

**HOW do phoebes acquire their song:
1) through learning or 2) innate?**



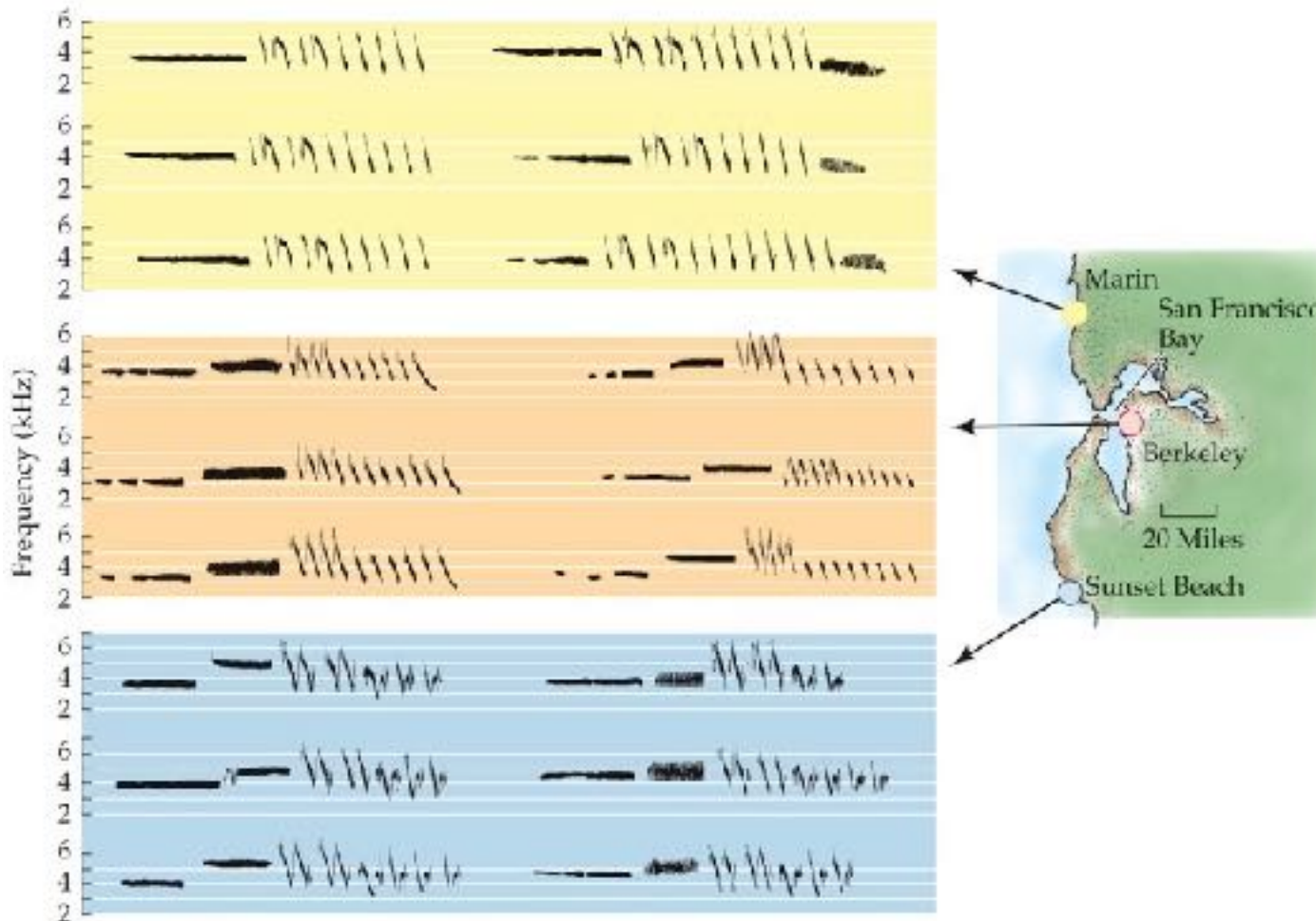
Eastern Phoebe



study 2:
two competing hypotheses
(hypotheses are within one level of analysis)

Observation: Songs vary regionally

- White-crowned sparrows have dialects
 - Geographic intraspecific variation in song



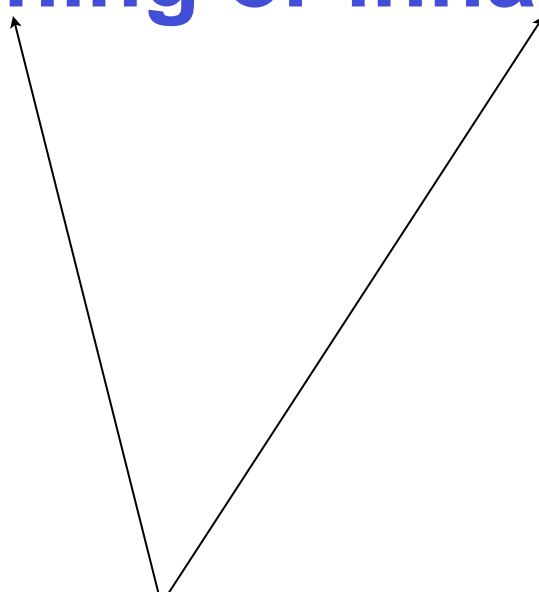
Alaska



Washington



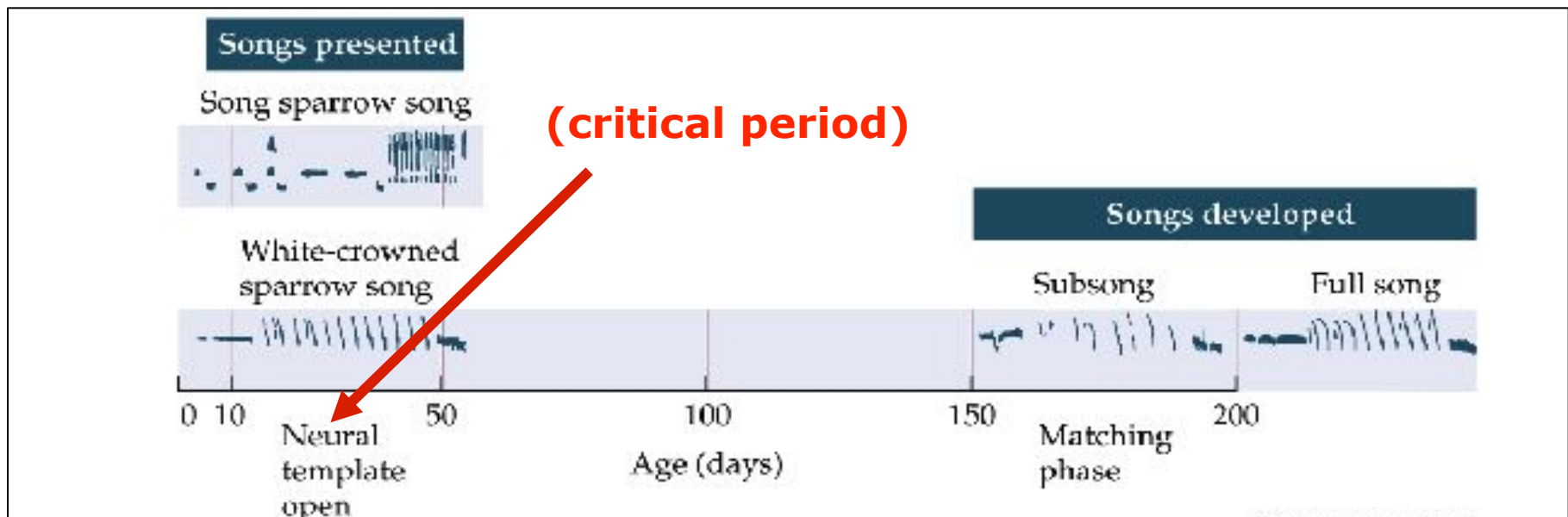
Ontogenic hypotheses for song variation: learning or innate development



both are ontogenetic (developmental) hypotheses, so they can compete

Ontogenic hypotheses for song variation: learning or innate development

- White-crowned sparrows hand-reared in lab demonstrate need to learn
 - Lone (isolated) birds began singing after 150 days ...but song is lame (twittering)
 - When 10- to 50-day-olds exposed to songs of any same-species dialect, they sang **that** song!
 - Do not learn song of different species

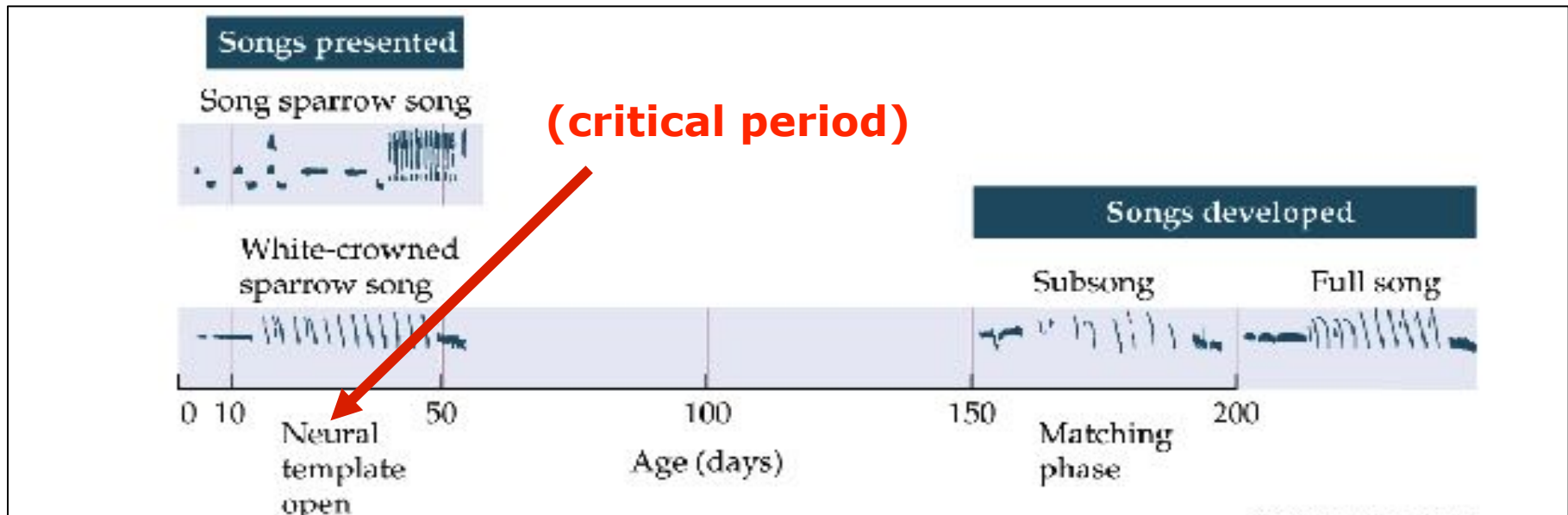
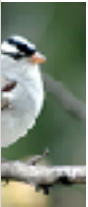


Ontogenic hypotheses for song

RESULTS: both innate template and learning hypotheses supported

(note: having support for more than one competing hypothesis is okay)

- When 10- to 50-day-olds exposed to songs of any same-species dialect, they sang **that** song!
- Do not learn song of different species



study 3:
two non-competing hypotheses
(hypotheses are from different levels of analysis)

Observation: there is sexual difference in song: males sing more than females



Zebra Finch

Observation: there is sexual difference in
song: males sing more than females

Ontogenetic hypothesis:



Zebra Finch

Mechanistic hypothesis:

different levels of analyses, so they
cannot compete

*but both could be true...

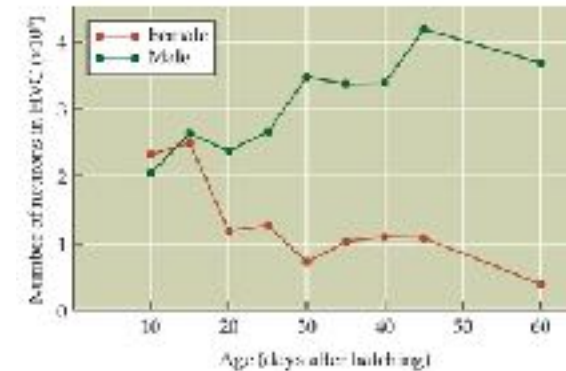
Observation: there is sexual difference in song: males sing more than females

Ontogenetic hypothesis: sex difference is due to differences brain development

- During development, genes on W chromosome are expressed — preventing testes development in females, which cause hormonal differences (and cascading effects) that lead sexual differentiation, including smaller HVC in females



Zebra Finch



Mechanistic hypothesis:

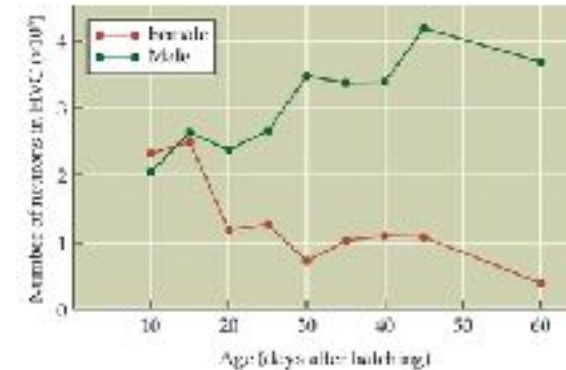
Observation: there is sexual difference in song: males sing more than females

Ontogenetic hypothesis: sex difference is due to differences brain development

- During development, genes on W chromosome are expressed — preventing testes development in females, which cause hormonal differences (and cascading effects) that lead sexual differentiation, including smaller HVC in females

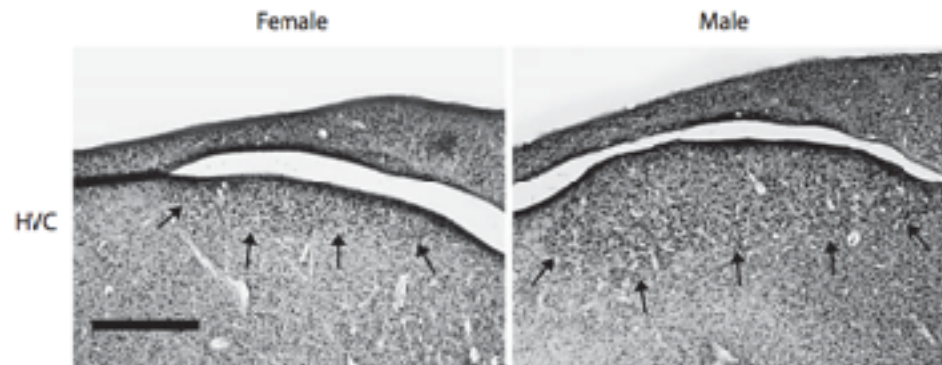


Zebra Finch



Mechanistic hypothesis: sex difference is due to size differences HVC

- Male HVC are larger in males in most songbirds



Observation: there is sexual difference in song: males sing more than females

Ontogenetic hypothesis: sex difference is due to differences brain development



Zebra Finch

- During development, genes on W chromosome are expressed — preventing testes development in females, which cause hormonal differences (and cascading effects) that lead sexual

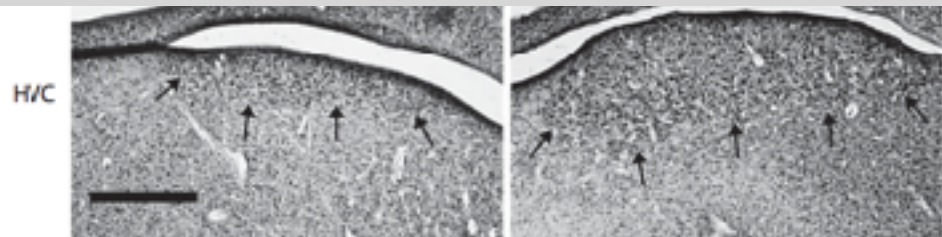


=BAD SCIENCE IF ARGUE ONE HYPOTHESIS AGAINST OTHER

***even when both can be true...**

Me
due

- Males in most songbirds



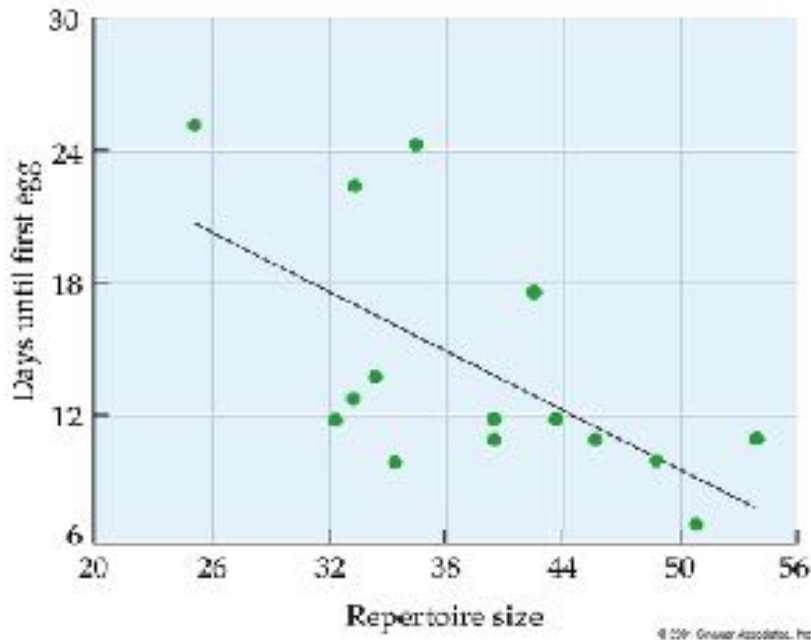
study 4-5:
three competing hypotheses
(tested on different species)
(hypotheses are within one level of analysis)

Observation: Only few groups of birds learn to sing (most birds have innate song)

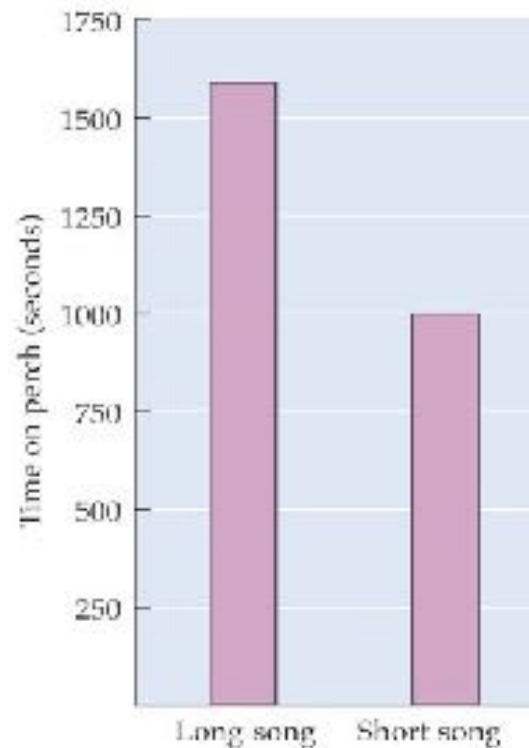
Is there an adaptive benefit for birds to learn songs?

Functional hypothesis for song learning: impressing females

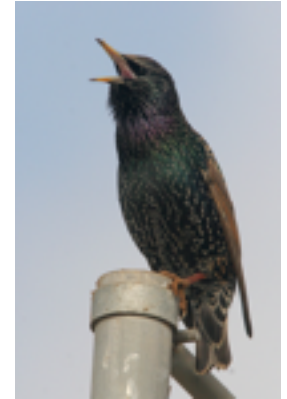
- Females prefer larger repertoires: it is attractive to be plastic



Males with large
repertoires chosen first



Males with long
songs preferred



Starling

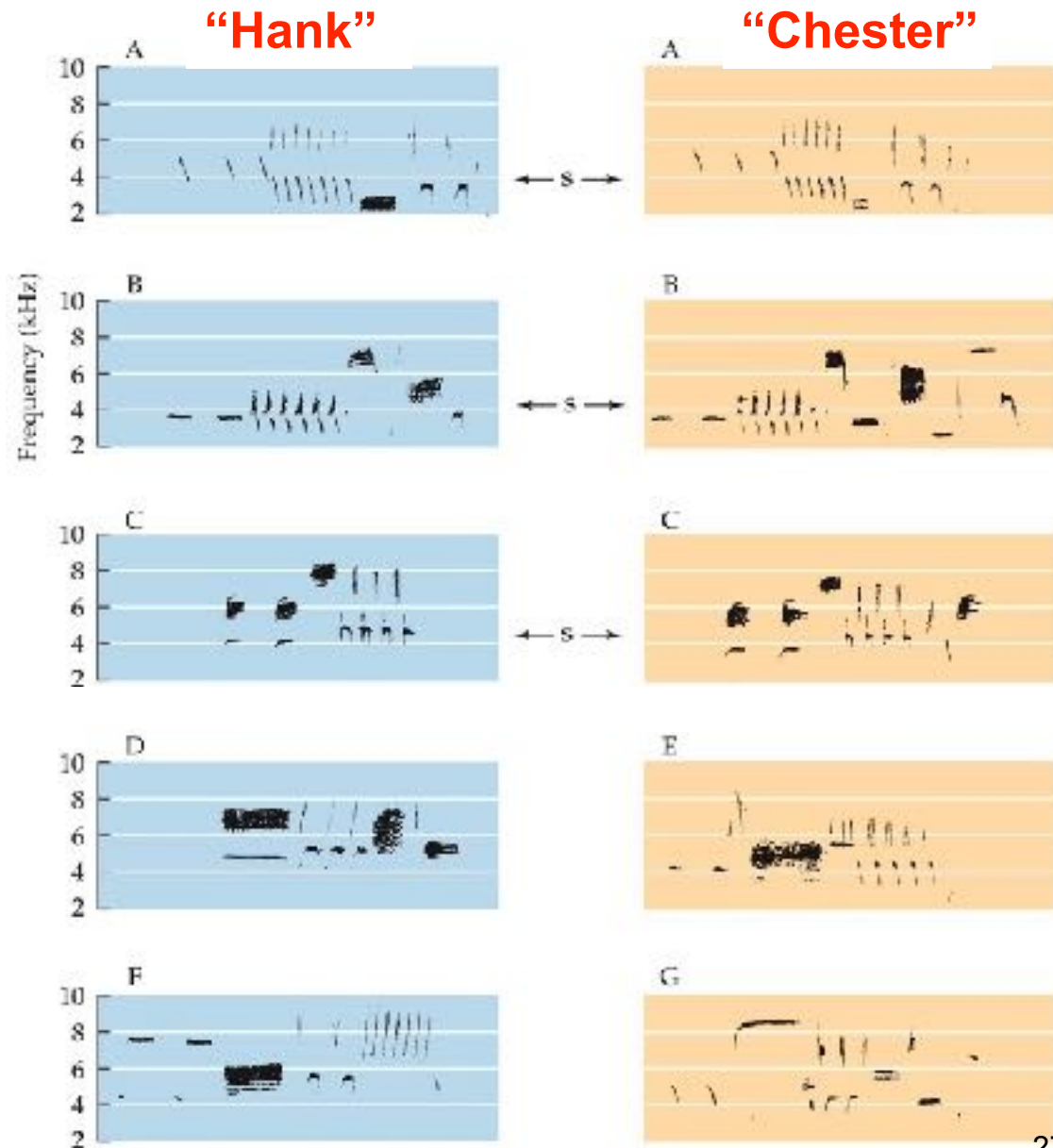


Functional hypothesis for song learning: defense of territory via counter-singing

- Birds learn neighbors' songs
- Song type matching
 - plasticity allows communication of degree of aggression

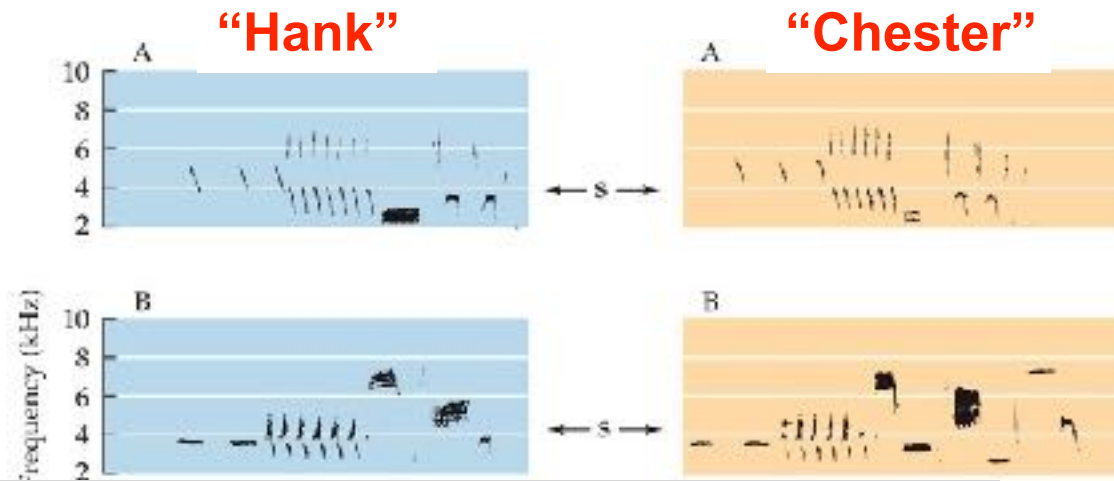


song sparrow



Functional hypothesis for song learning: defense of territory via counter-singing

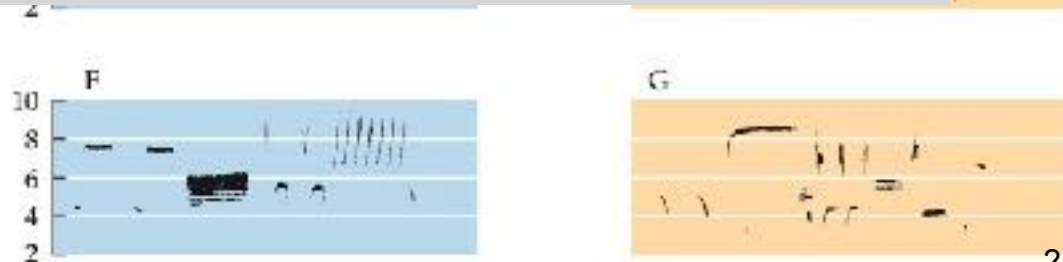
- Birds learn neighbors' songs
- Song type matching
 - plasticity allows communication of



RESULTS: many hypotheses are supported (for different species) for adaptive benefit of learning song



song sparrow



study 6:
two competing hypotheses
(hypotheses are within one level of analysis)

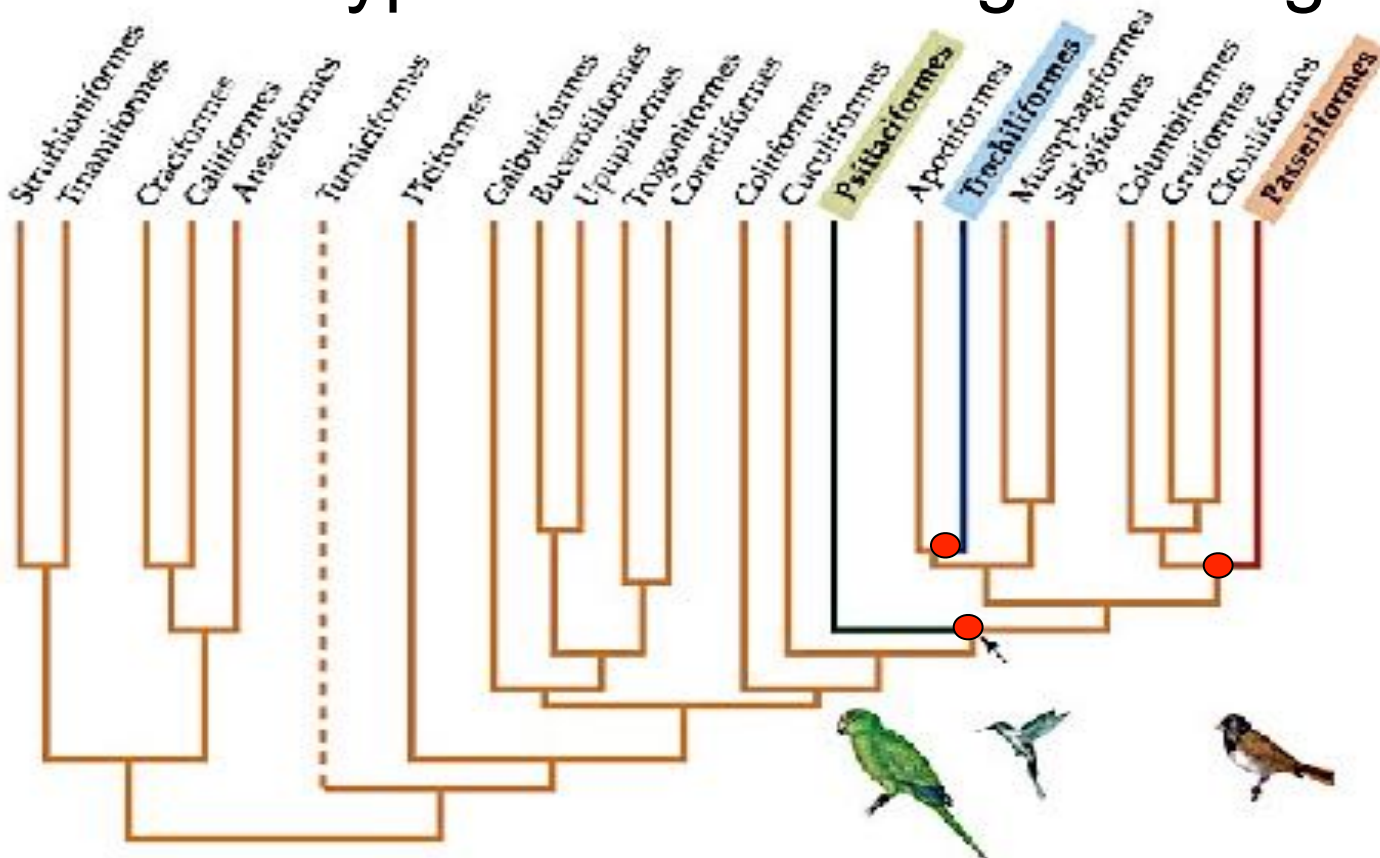
Observation: Only few groups of birds learn to sing (most birds have innate song)

Why did some birds evolve to learn songs and others did not?

Observation: Only few groups of birds learn to sing (most birds have innate song)

Why did some birds evolve to learn songs and others did not?

Historic hypotheses for song learning



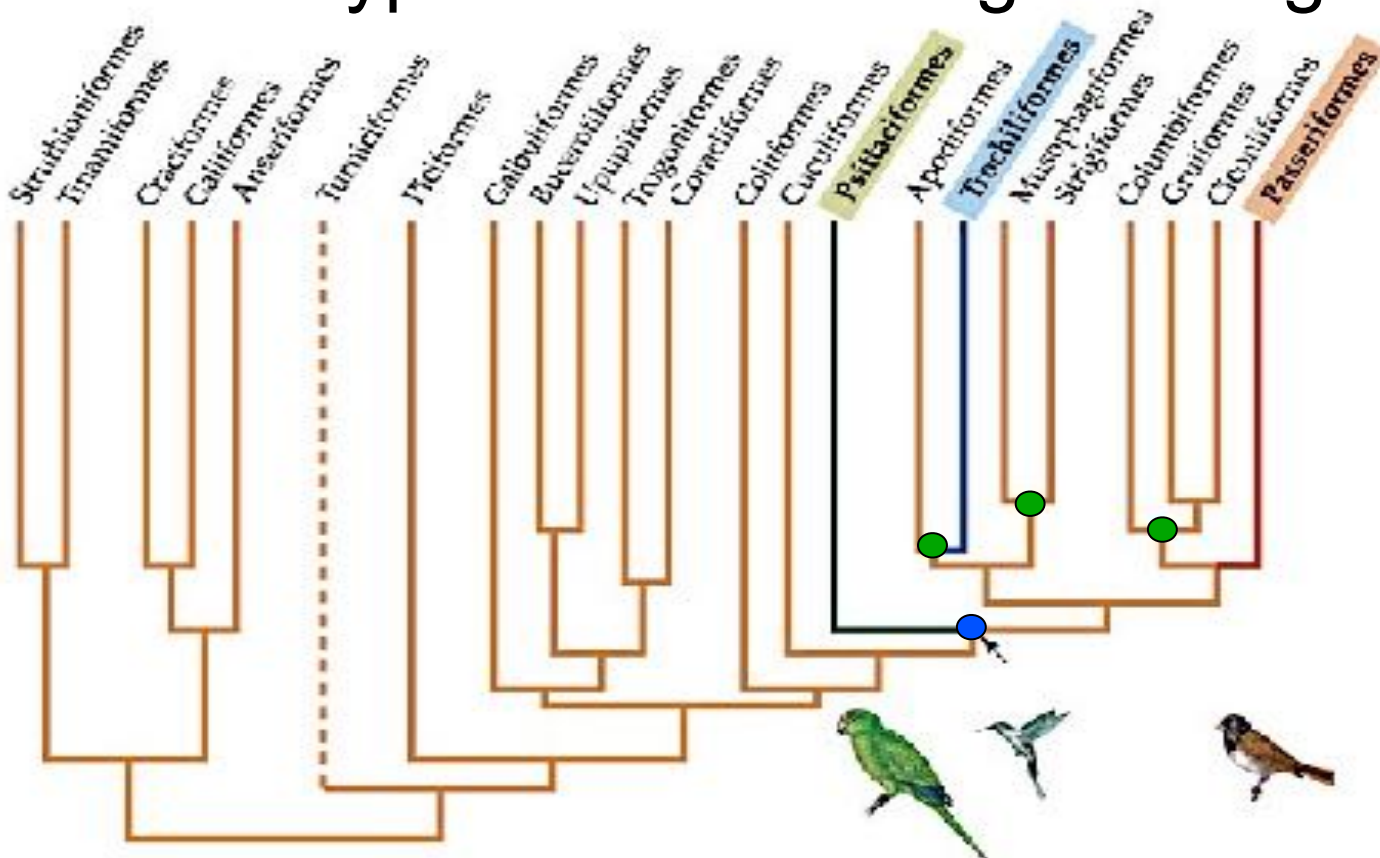
Evolved via:

- H1: three gains (3 red dots) = 3 steps

Observation: Only few groups of birds learn to sing (most birds have innate song)

Why did some birds evolve to learn songs and others did not?

Historic hypotheses for song learning



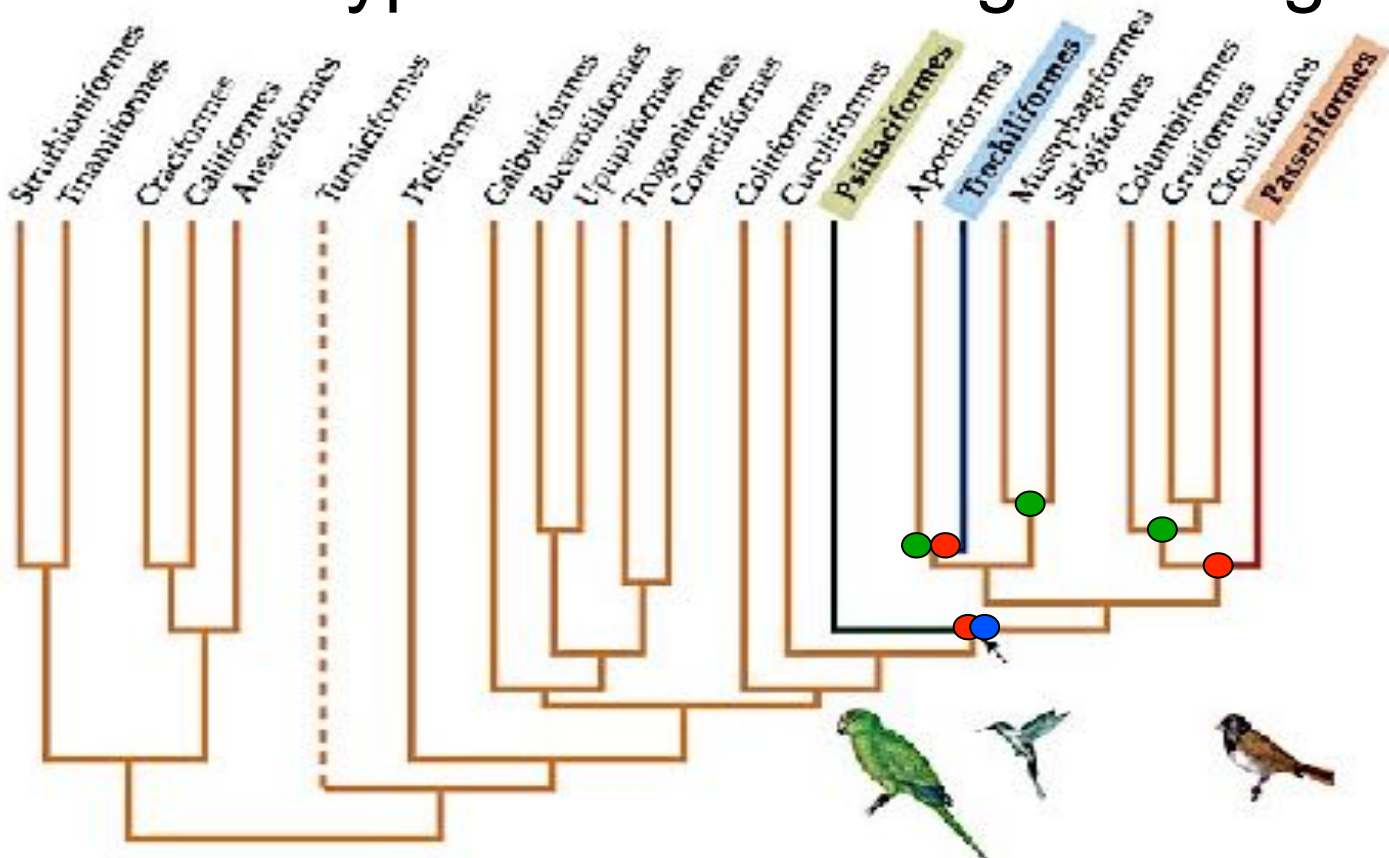
Evolved via:

- H1: three gains (3 red dots) = 3 steps
- or
- H2: one gain (1 blue dot) followed by three losses (3 green dots) = 4 steps

Observation: Only few groups of birds learn to sing (most birds have innate song)

Why did some birds evolve to learn songs and others did not?

Historic hypotheses for song learning



Evolved via:

- H1: three gains (3 red dots) = 3 steps
- or
- H2: one gain (1 blue dot) followed by three losses (3 green dots) = 4 steps

Observation: Only few groups of birds learn to sing (most birds have innate song)

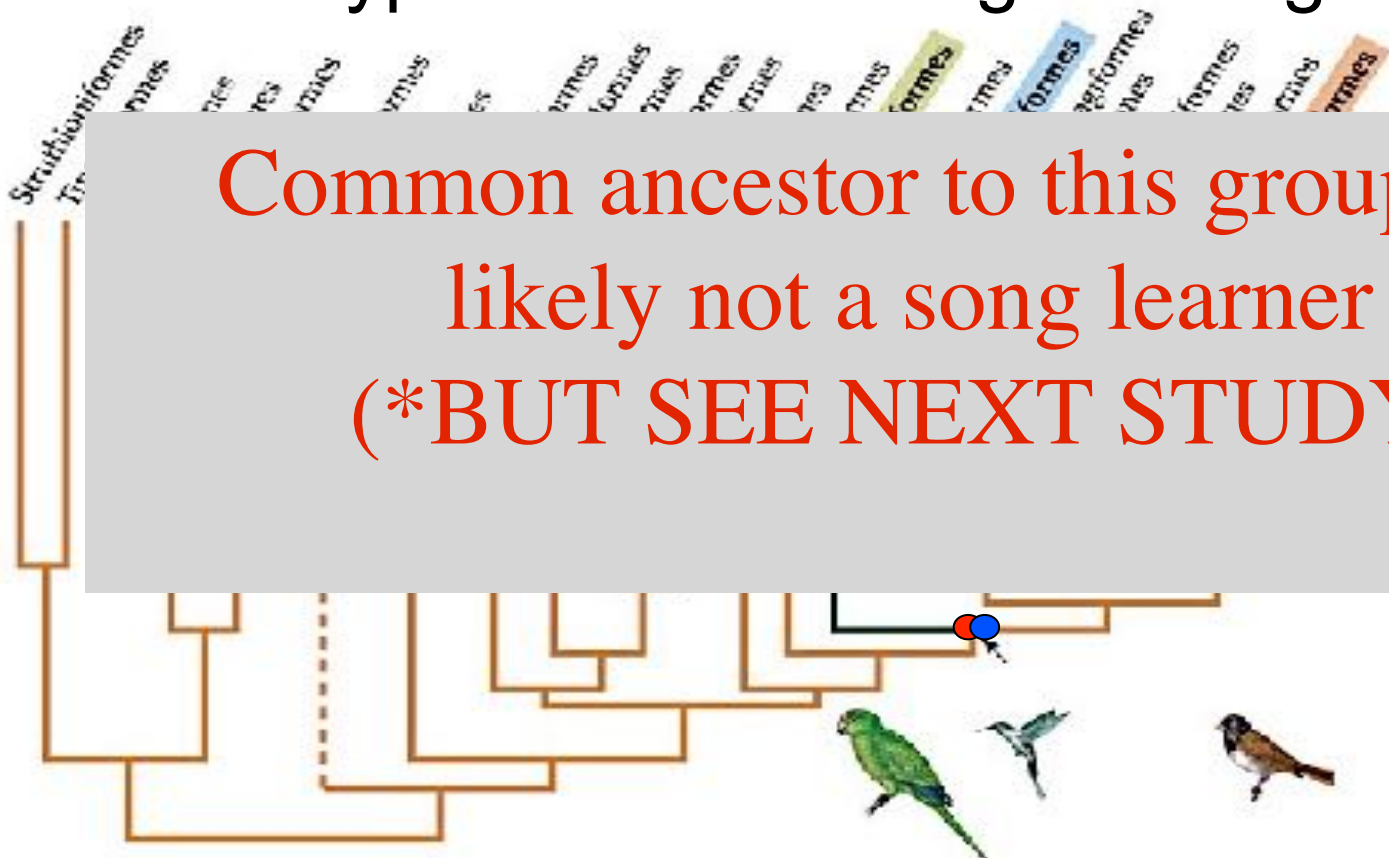
Why did some birds evolve to learn songs and others did not?

Historic hypotheses for song learning

Evolved via:

- H1: three

Common ancestor to this group was likely not a song learner (*BUT SEE NEXT STUDY)



three losses (3 green dots) = 4 steps

How can levels of analysis
complement each other?

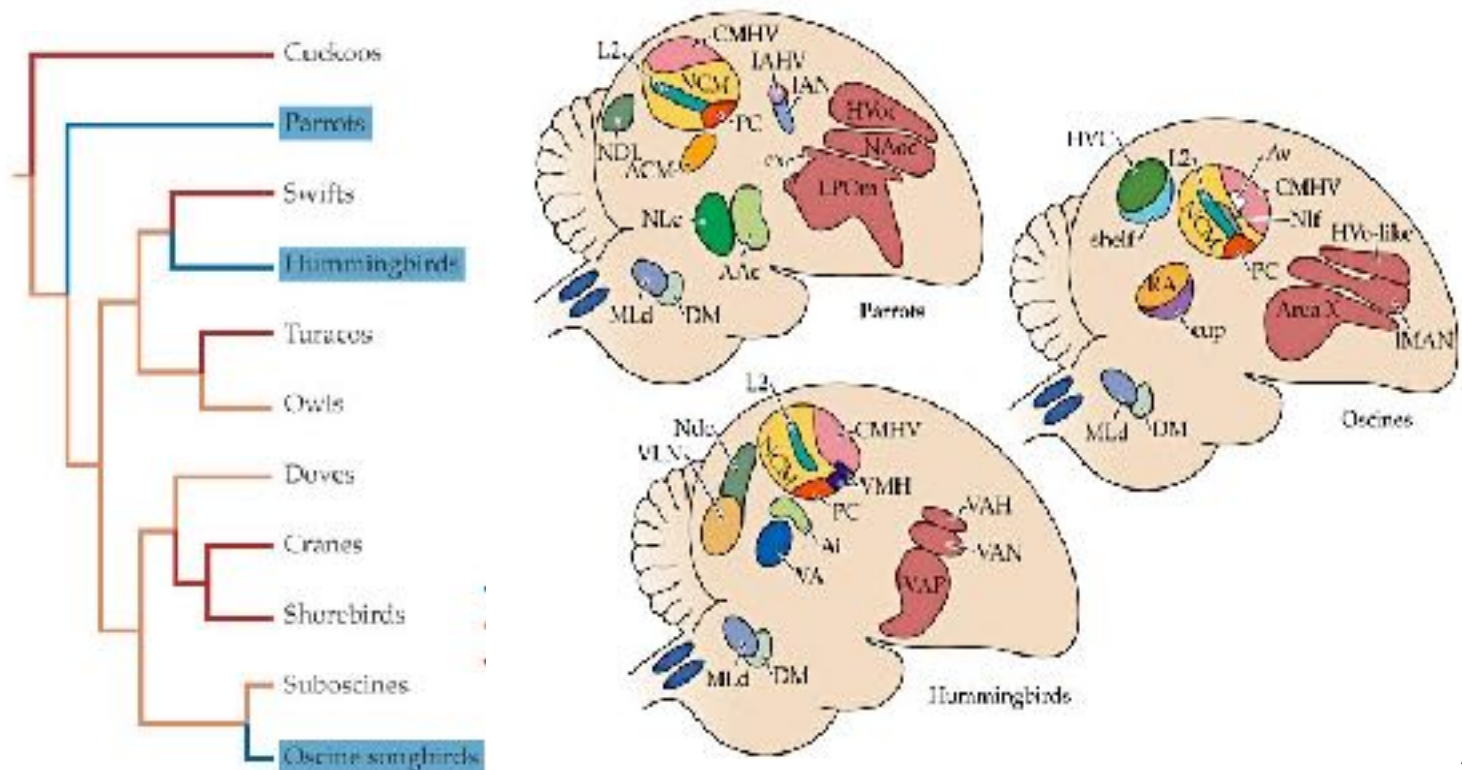
Historic explanation can be enhanced by knowledge of mechanism

**How is song learning neurally
organized?**

Historic explanation can be enhanced by knowledge of mechanism

How is song learning neurally organized?

- Brain anatomy and regulatory genes and neural control centers are similar for all three groups of singers

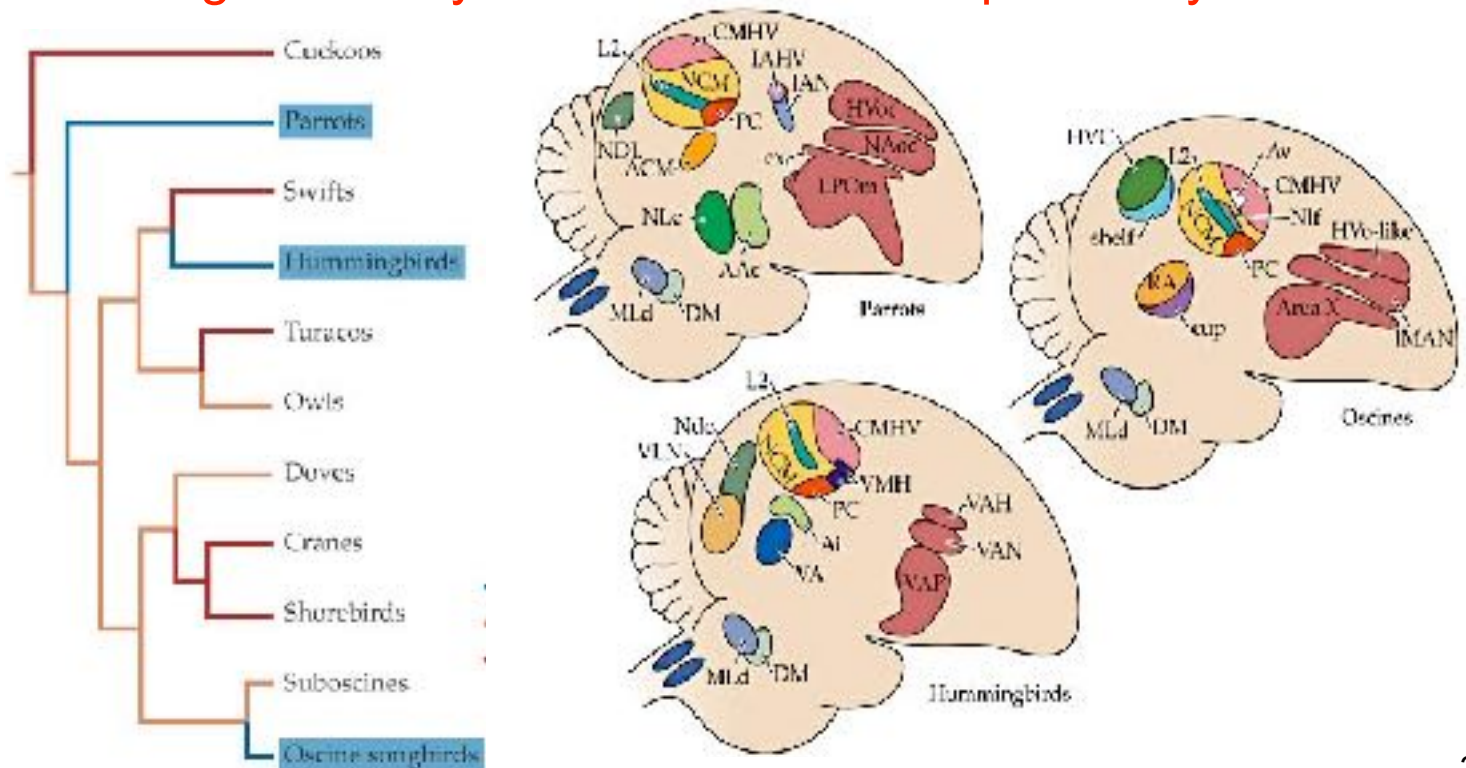


Historic explanation can be enhanced by knowledge of mechanism

How is song learning neurally organized?

- Brain anatomy and regulatory genes and neural control centers are similar for all three groups of singers

-- thus information based on mechanism inform historic hypothesis.... in this case: that song is unlikely to have evolved independently three times

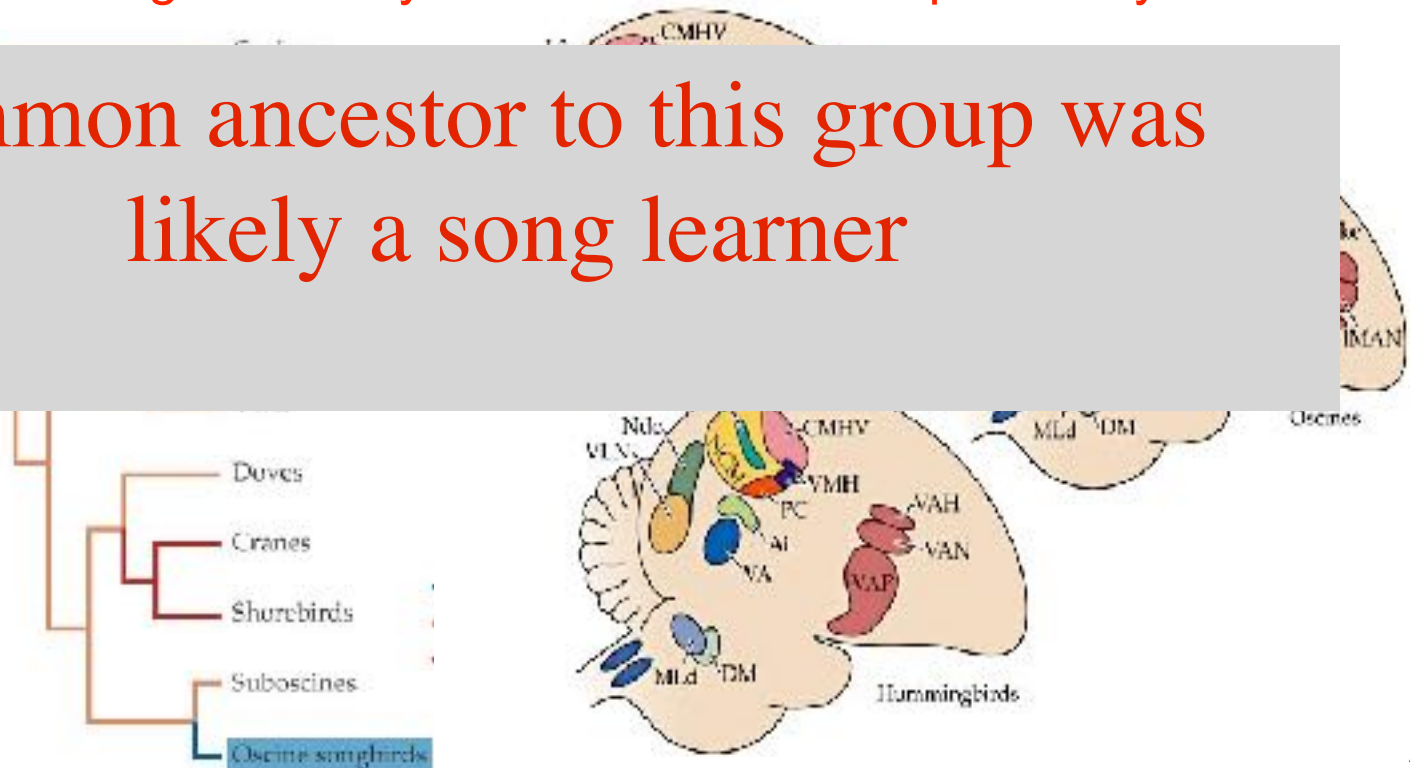


Historic explanation can be enhanced by knowledge of mechanism

How is song learning neurally organized?

- Brain anatomy and regulatory genes and neural control centers are similar for all three groups of singers
 - thus information based on mechanism inform historic hypothesis.... in this case: that song is unlikely to have evolved independently three times

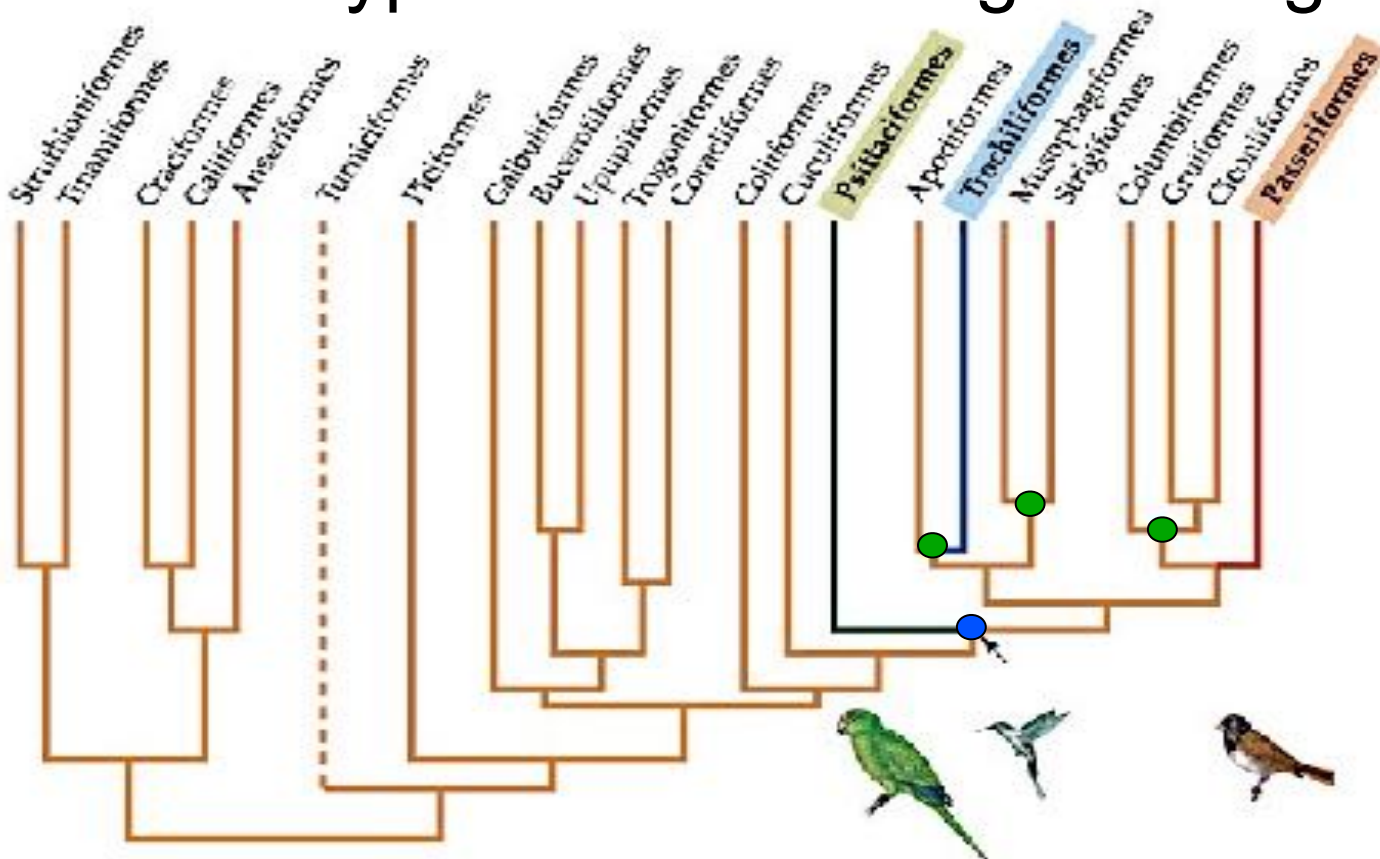
Common ancestor to this group was likely a song learner



Observation: Only few groups of birds learn to sing (most birds have innate song)

Why did some birds evolve to learn songs and others did not?

Historic hypotheses for song learning



Evolved via:

- H1: three gains (3 red dots) = 3 steps

or

- H2: one gain (1 blue dot) followed by three losses (3 green dots) = 4 steps

Historic explanation can be enhanced by knowledge of mechanism

How is song learning neurally organized?

- Brain anatomy and regulatory genes and neural control centers are similar for all three groups of singers
 - thus information based on mechanism inform historic hypothesis.... in this case: that song is unlikely to have evolved independently three times

Common ancestor to this group was likely a song learner

Studies from different levels can complement one another to clarify whole picture of phenomenon