Avian Systematics

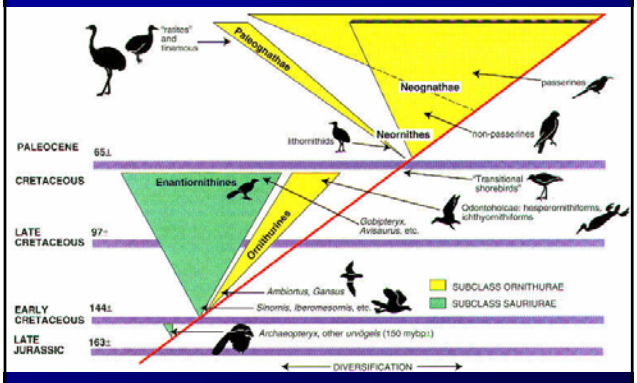
- The goal of systematics (and classification) is to provide a correct phylogeny (evolutionary family tree) for organisms.
- Avian systematics deals with how the phylogeny of modern birds is established.

Avian Systematics

- Systematics deals with evolutionary relationships among organisms. Allied with classification (or taxonomy).
- All birds are classified within the single Class Aves
  - 2 Subclasses
  - 4 Infraclasses

Class Aves

- Subclass Sauriurae
  - Infraclass Archaeornithes - *Archaeopteryx*
  - Infraclass Enantiornithes - Opposite birds
- Subclass Ornithurae
  - Infraclass Odontornithes - New World toothed birds
  - Infraclass Neornithes
    - Superorder Paleognathae - ratites and tinamous
    - Superorder Neognathae - all other birds



Avian Phylogeny based on Feduccia (1995)

Avian Systematics

- **Living birds comprise approximately**:
  - 30 Orders
  - 193 Families
  - 2,099 Genera
  - 9,700 species

Avian Systematics

- Basic unit of classification = Species

I. Speciation

Central question > Origin of species

A. What is a species?

1. BSC – groups of interbreeding natural populations that are reproductively isolated from other such groups (Mayr 1970)

What does one use to group taxa?

- size
- color
- behavior
- genetics

What are the problems associated with using this definition?

When populations hybridize we can directly define a species. What if two populations are separated?

Thompson 1991 Condor 93:987-1000

Painted Bunting

Phylogenetic Species Concept

PSC – a species is the smallest aggregation of populations diagnosable by a unique combination of character states in individuals within which there is a parental pattern of ancestry and descent

- Approach gives greater weight to recognition of separate evolutionary histories of isolated populations.
- Less emphasis placed on development of reproductive isolation.

Rose-breasted Grosbeak & Black-headed Grosbeak

•American Ornithologists' Union Committee on Classification and Nomenclature only recognizes BSC.

B. Allopatric speciation

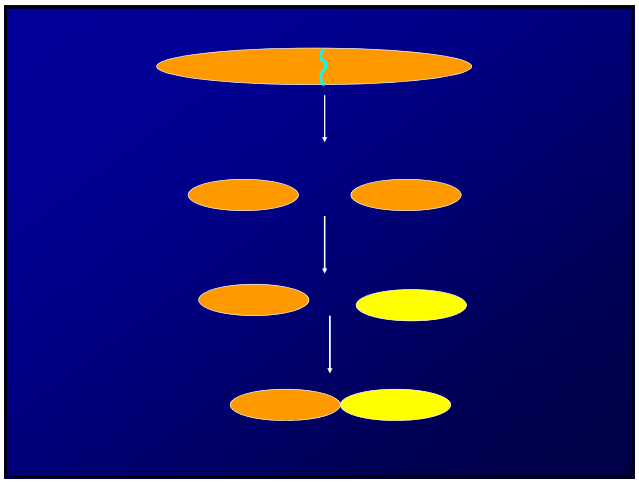
1. Operates in 4 steps

a. Reproductive isolation occurs because of physical, geographic separation of two populations.

b. Isolated populations undergo independent evolution and become adapted to separate environments.

c. Reproductive isolation must evolve so that mechanisms occur to reduce interbreeding between populations.

d. If geographic isolation stops and the two populations come into contact and if some reproductive isolating mechanism has evolved, speciation is complete.



Allopatric speciation – primary mode in birds. Evidence for others weak.

2. Reproductive Isolating Mechanisms

Prezygotic – Fertilization and Zygote fomation prevented

- Habitat
- Seasonal or Temporal
- Ethological
- Mechanical

Postzygotic – Fertilizations take place and hybrid zygotes are formed but are inviable or give rise to weak or sterile hybrids.

In birds, mechanisms can be obvious

- size
- plumage pattern
- song
- behavioral displays

Size

Plumage pattern/color

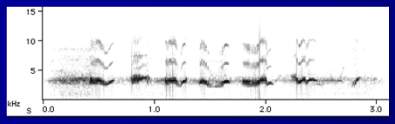
Baltimore Oriole

Icterus galbula

Orchard Oriole

Icterus spurius

Song



Willow Flycatcher – liquid *wit*

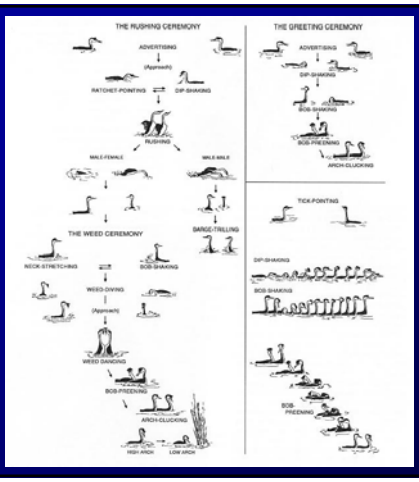
Alder Flycatcher – loud *pip*

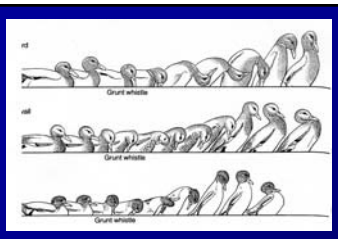
Behavior

Robert Storer – 1960's

Clark's Grebe

Western Grebe

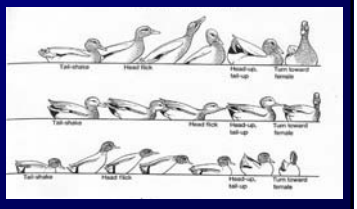




Mallard

Gadwall

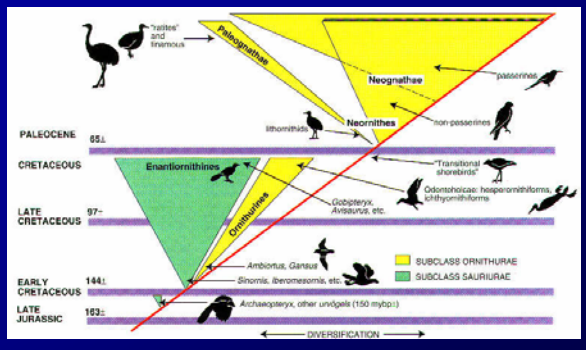
GW Teal



Mallard

Gadwall

GW Teal



C. Speciation resulting from Pleistocene Glaciations

1. Early Tertiary

Need to go back to early Tertiary ~ 50mya

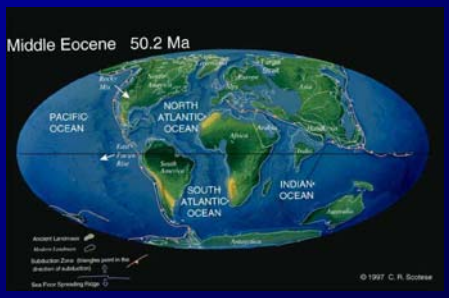
Time of major adaptive radiation

	Period	Epoch	Date
Cenozoic	Quaternary	Pleistocene	10,000 to 2 million
	Tertiary	Pliocene	2 to 5 million
		Miocene	**5 to 24 million**
		Oligocene	24 to 38 million
		Eocene	38 to 55 million
		Paleocene	55 to 63 million
Mesozoic	Cretaceous		63 to 138 million
	Jurassic		138 to 205 million
	Triassic		205 to 240 million
Paleozoic	Permian		240 to 290 million
	Carboniferous		290 to 365 million
	Devonian		365 to 410 million
	Silurian		410 to 435 million
	Ordovician		435 to 500 million
	Cambrian		500 to 570 million
Precambrian			570 to 4,500 + million

•Tropical environments as far north as Canadian border

•North America void of mountains, climate uniform

•Ocean beaches north as far as San Antonio area



Fossil evidence of 3 distinct floras

a. Neotropical-Tertiary – Broadleaf evergreen types (tropical and subtropical forests)

b. Arcto-Tertiary – 2 subunits

   i. Boreal unit – pines, spruce, willow, birch

   ii. Temperate unit – maple, chestnut, dogwood, beech, ash, oak, elm

c. Madro-Tertiary – Minor assemblage on the Mexican Plateau and consisted of mesquite, creosote bush, acacia, junipers, and yucca.

2. Late Tertiary

Oligocene (38mya) climate started becoming cooler.

Miocene – Rockies begin uplift, major vegetational changes.

• Neotropical-Tertiary retreated south into Central America (left Magnolia in southeast). Grasslands in rain shadow of Rockies

• Arcto-Tertiary retreated south and occupied most of US (except Great Plains). Relic left in California and Pacific NW (sequoias)

• Madro-Tertiary extended into SW US

3. Pleistocene effects in North America

Climate change started in Oligocene continued and resulted in many (7-10) glacial advances in North America

	Period	Epoch	Date
Cenozoic	Quaternary	Pleistocene	10,000 to 2 million
	Tertiary	Pliocene	2 to 5 million
		Miocene	**5 to 24 million**
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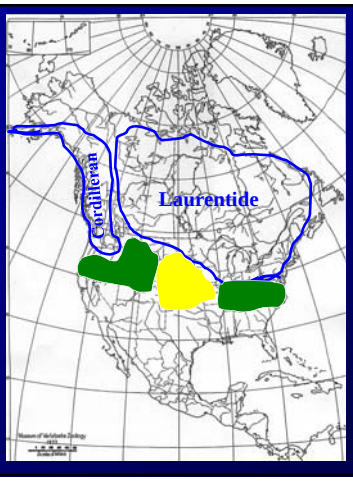
	Silurian		410 to 435 million
	Ordovician		435 to 500 million
	Cambrian		500 to 570 million
Precambrian			570 to 4,500 + million

Each glacial advance followed by interglacial.

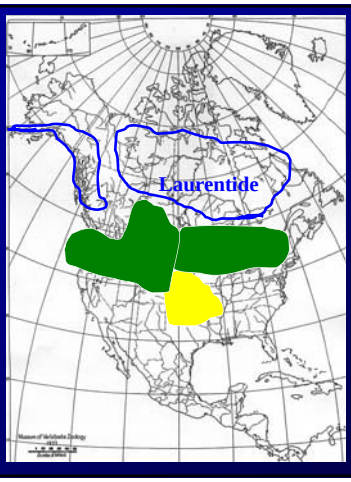
Resulted in compression of communities followed by release.

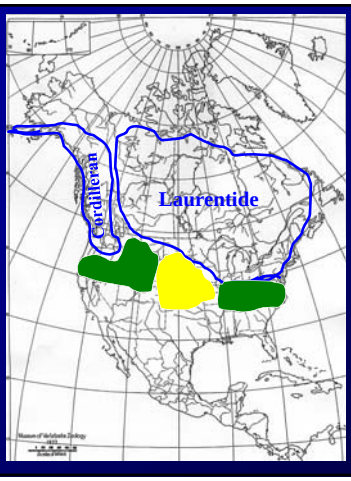
With each glacial advance, there was a separation of boreal forest into eastern and western components.



With each glacial retreat, there was a northward advance of the vegetative zones,

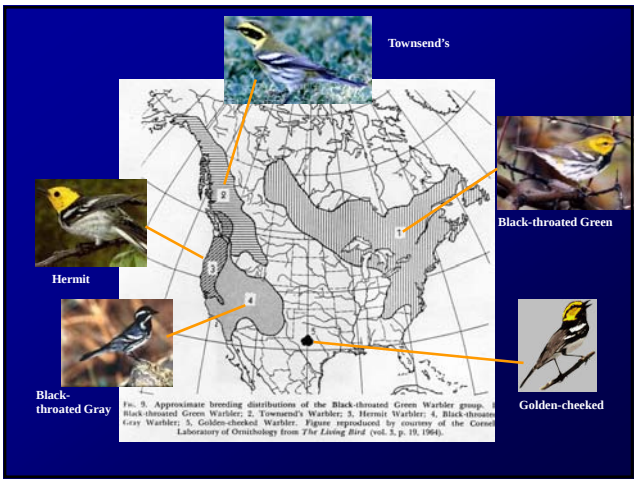
boreal formed continuous belt across continent.





Black-throated Green Warbler Complex

- Black-throated Green
- Golden-cheeked
- Black-throated Gray
- Hermit
- Townsend's



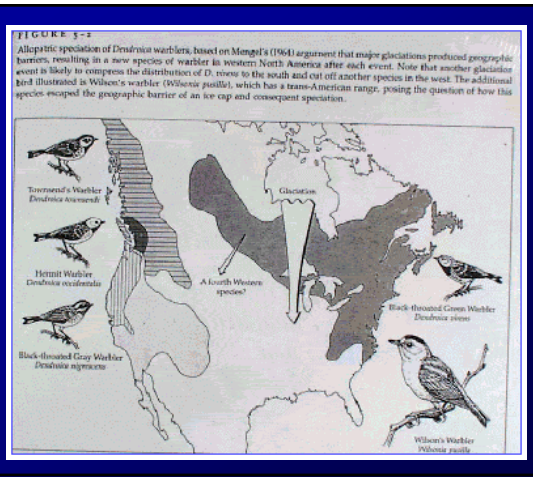


FIGURE 5-2
Allopatric speciation of *Dendroica* warblers, based on Mengel's (1964) argument that major glaciations produced geographic barriers, resulting in a new species of warbler in western North America after each event. Note that another glaciation event is likely to compress the distribution of *D. nivea* to the south and cut off another species in the west. The additional bird illustrated is Wilson's warbler (*Wilsonia pusilla*), which has a trans-American range, posing the question of how this species escaped the geographic barrier of an ice cap and consequent speciation.

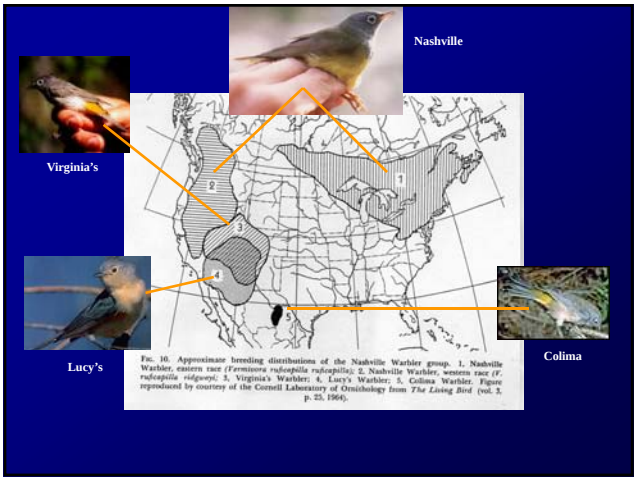
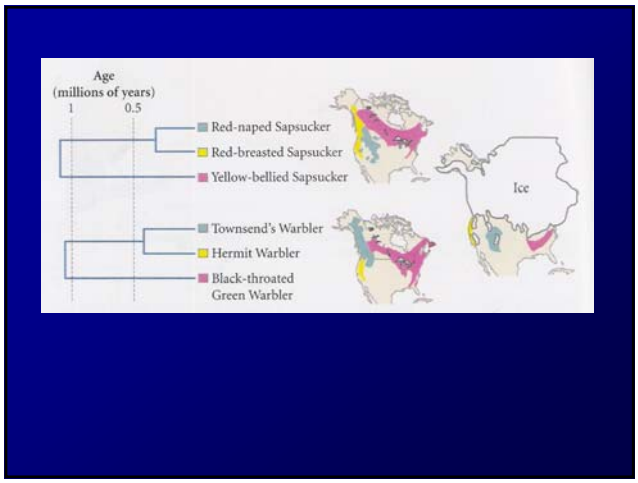
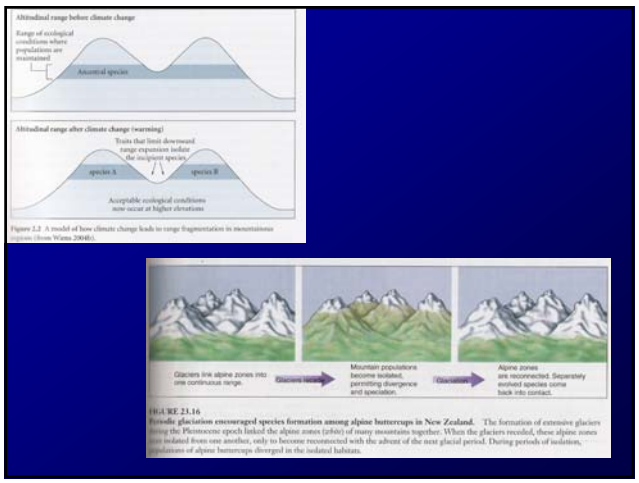


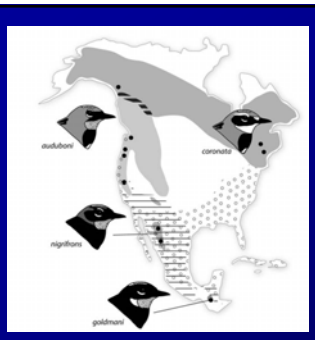
FIG. 10. Approximate breeding distributions of the Nashville Warbler group. 1, Nashville Warbler, eastern race (*Vermivora ruficapilla ruficapilla*); 2, Nashville Warbler, western race (*V. ruficapilla ridgwayi*; 3, Virginia's Warbler; 4, Lucy's Warbler; 5, Colima Warbler. Figure reproduced by courtesy of the Cornell Laboratory of Ornithology from *The Living Bird* (vol. 3, p. 23, 1964).



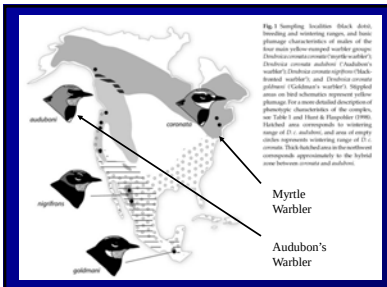


What do we know now?

Bermingham et al. 1992 PNAS 89:6624-6628



Milá et al. 2007. Speciation and rapid phenotypic differentiation in the yellow-rumped warbler complex. Molecular Ecology 16:159-173.

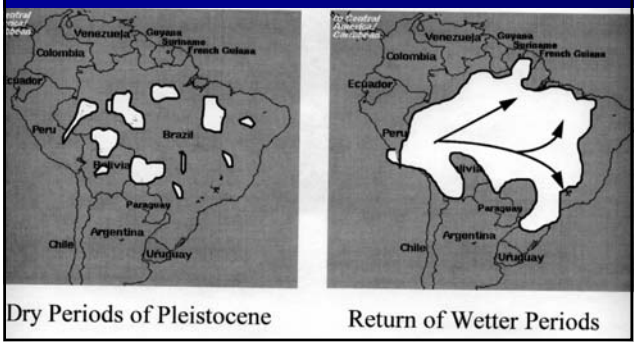


mtDNA reveal sedentary Mesoamerican forms are monophyletic to each other and other Yellow-rumped Warbers.

- All diverged in early Pleistocene
- Differentiation between migratory forms during Holocene

4. Pleistocene effects in South America

Pleistocene Refugia



D. Hybridizations

When reproductive barriers complete, so is speciation.

Barriers can break down.

Great Plains well known hybrid zone (14 pairs known to interbreed)

1. American Black Ducks

American Black Duck

Mallard

2. Eastern, Western and Mountain Bluebirds

E. Geographic Variation

Many spp have broad distributions

Often not morphologically uniform throughout range but vary in response to local conditions.

Populations represent reproductive continuum, connected over continent.

Evolution depends on relative strength of 2 forces

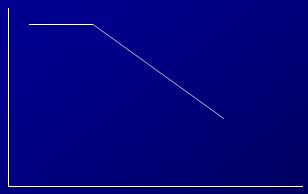
Natural Selection and Gene Flow

Natural Selection – promotes divergence

Gene Flow – opposes divergence by blending differences.

Clines – gradients of character states

Expressions of opposing actions of NS and Gene Flow.



1/3 NA species show geographical variation (subspecies)

Subspecies – 75% of individuals in region are distinguishable by their plumage or size.

Oregon Junco

Pink-sided Junco

Slate-colored Junco

Gray-headed Junco

Song Sparrow – breeds throughout NA.

31 distinct subspecies identified.

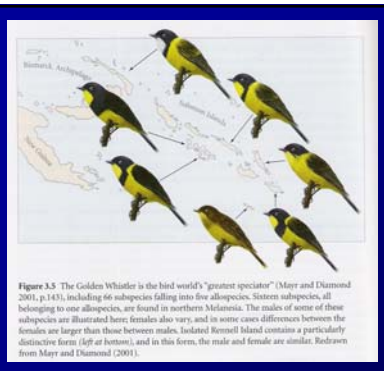


Figure 3.5 The Golden Whistler is the bird world's "greatest speciator" (Mayr and Diamond 2001, p.143), including 66 subspecies falling into five allospecies. Sixteen subspecies, all belonging to one allospecies, are found in northern Melanesia. The males of some of these subspecies are illustrated here; females also vary, and in some cases differences between the females are larger than those between males. Isolated Rennell Island contains a particularly distinctive form *(left at bottom)*, and in this form, the male and female are similar. Redrawn from Mayr and Diamond (2001).

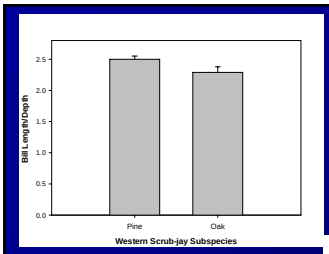
Greatest Speciator

Golden Whistler
66 subspecies

Geographic variation can evolve because different environments favor different attributes.

Western Scrub Jays

Bardwell et al. 2001. Ecology 82:2617-2627



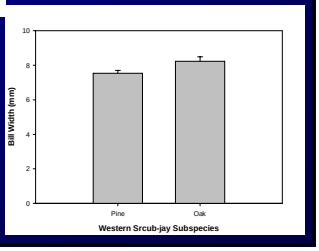


FIG. 1. Distribution of Western Scrub-Jays (in black adapted from Peterson [1993]), the locations where scrub-jays were captured (at end of arrows), and representative scrub-jays and food resources used in the experiments. The scrub-jays depicted are representative of the typical bill structure found within each population and were traced from photographs. The open pinyon pine (*Pinus monophylla*) cone and seed (upper right) and coastal live oak (*Quercus agrifolia*) acorns (lower left) are drawn to relative scale (reproduced from Sudworth [1967]).

Trade-off in feeding performance

- pine scrub-jays extracted and consumed pinyon seeds more than 30% faster than oak scrub-jays
- oak scrub-jays consumed acorns 2x as fast as pine scrub-jays

Individuals at opposite ends of a cline can be very different, but because connected by interbreeding forms regarded as same species.

Ring species –

Herring Gull ⟺ Lesser Blackbacked Gull

Ring species – chain of intergrading populations encircles a barrier and the terminal forms coexist without interbreeding

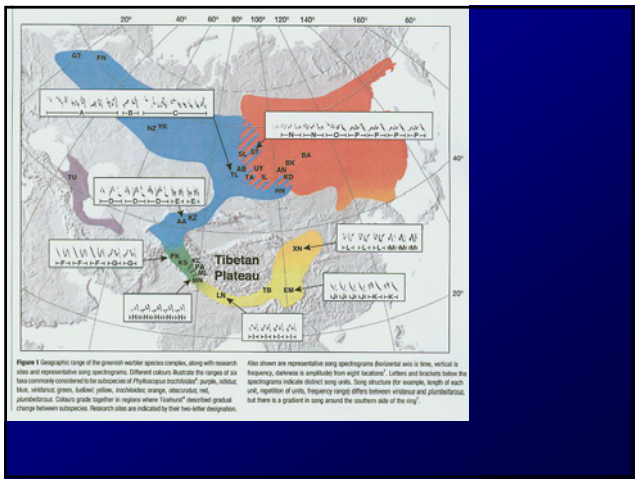
Greenish Warbler Complex

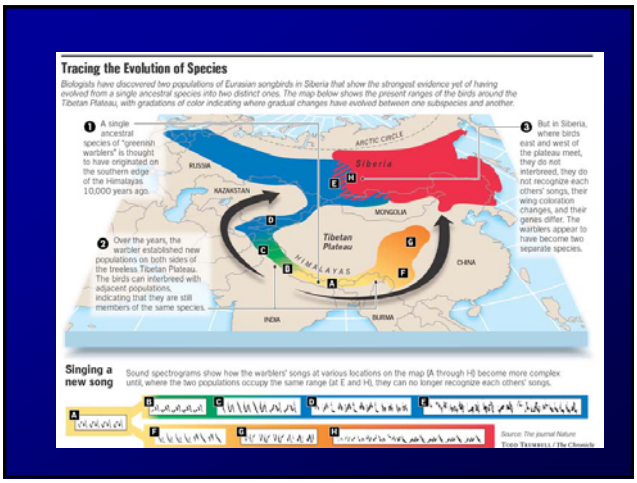
Irwin et al. 2001. Nature 409:333

Lives in foothills of Himalayas

Song changes gradually over territories

Extreme ends of range, sings very different songs and does not recognize neighbors





Ultraviolet plumage reflectance

Long assumed that differences along cline due to local environment.

Are differences genetic or environmentally induced?

How could we test this?

James 1983. Science 221:184-186

Geographic Variation in Red-winged Blackbird

Florida

- Tallahassee – long bill
- Everglades – short bill

Midwest

- Minnesota – long wings, toes
- Colorado – short wings, toes

Red-winged Blackbird

Transplanted birds resembled foster parents!!

But not a complete morphological shift,

thus genetic component as well

Back