

# Lect. 11. Geographic Variation (continued), Factors that discourage gene flow

EEB 2245, C. Simon, 15 Mar 11

## Definitions (review)

- Population- groups of individuals of the same species that interbreed with other individuals in their population and only rarely with migrants from other populations. Two populations may be...
- Sympatric- geographic overlapping
- Allopatric- geographically separate
- Parapatric- geographically adjacent
- Allochronic- separated in time

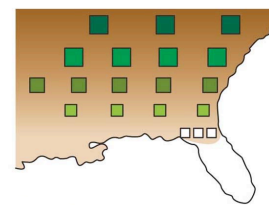
## Cline definition

- Cline: a geographic change in allele frequency in one or more traits.

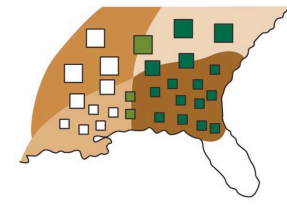
Step cline

Gradual cline

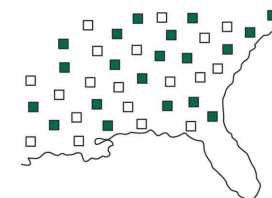
Fig. 9.22. From Futuyma 1975. Patterns of geographic variation e.g., size and color clines



Concordant clines: gradual size & color

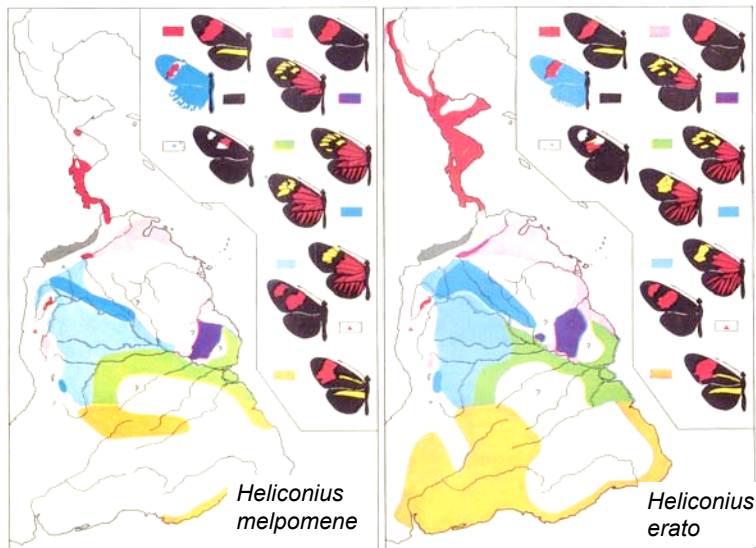


Perpendicular clines: N-S-gradual, size. E-W - abrupt, color.

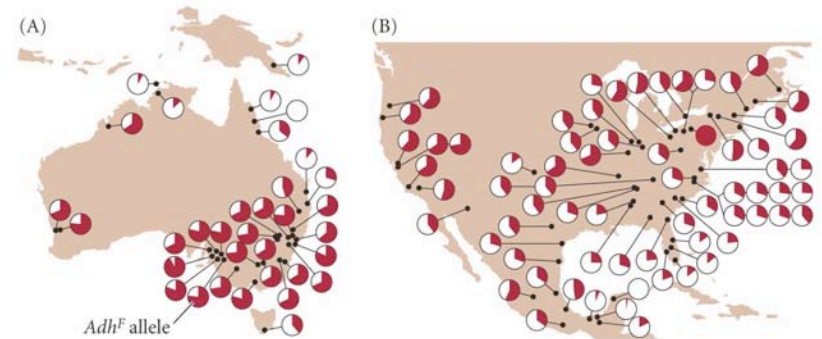


Mosaic abrupt color cline; no cline in size

## Stepped cline

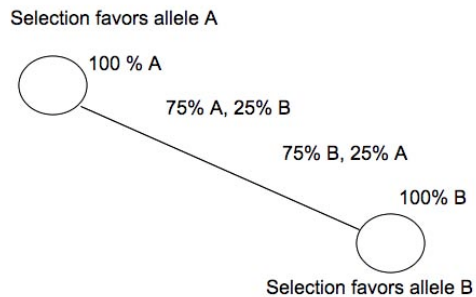


Gradual Cline: Fig. 9.28. High  $Adh^F$  allele frequency associated with colder latitudes; parallel clines on two continents.



## Reasons for clines

- 1) Correlation w environmental variables
- 2) Genetic Hitching
- 3) Secondary contact btw two formerly isolated populations- maintained by balance btw gene flow & selection.



## Definitions (cont.)

- Geographic race or subspecies- a genetically isolated subsection of a species whose individuals show more similarity to each other than to individuals from other races. Likely incipient species.
- Species- (next lecture) Definition depends on species concept.

Darwin said...

“I believe a well-marked variety may be justly called an incipient species....”

But with the qualification:

“It need not be supposed that all varieties or incipient species necessarily attain the rank of species. They may whilst in this incipient state become extinct, or they may endure as varieties for long periods....”

C. Darwin: “On The Origin of Species...” Ch II. Variation Under Nature

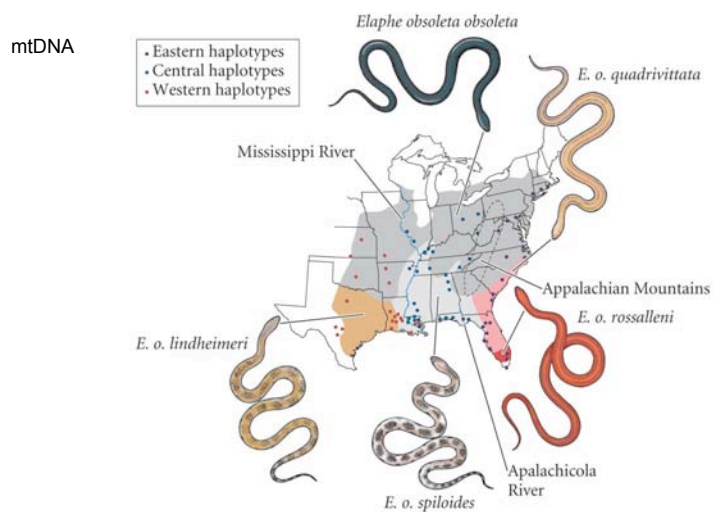
Darwin also pointed out...

“No clear line of demarcation has as yet been drawn between species...or, again, between sub-species and well-marked varieties, or between lesser varieties and individual differences.

These differences blend into each other in an insensible series....”

C. Darwin: “On The Origin of Species...” Ch II. Variation Under Nature

Fig. 9.26, Rat snake color-morphs were named subspecies but genetic analysis suggests otherwise



EVOLUTION, Figure 9.24 © 2005 Sinauer Associates, Inc.

## Rat Snakes

Burbrink et al. 2000.

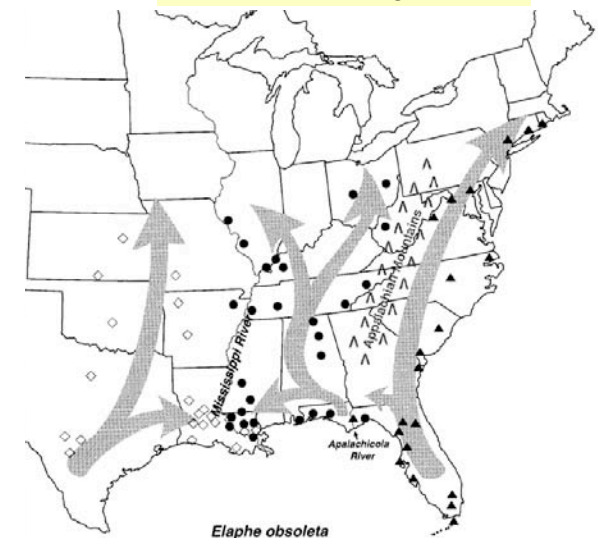
Three mtDNA lineages

Do not correspond to color pattern

Multivariate analysis of morphology independent of color pattern does match mtDNA pattern

Three pleistocene refugia & subsequent dispersal

Dark color pattern in north helps thermoregulation



## Are there geographic races or subspecies of rat snakes?

## Genetic Variation in Humans

Are humans divided into genetically identifiable subpopulations that fit the definition of geographic races?

## Genetic Variation in Humans (cont.)

Lewontin (1972) and Nei and Roychoudhury (1972)  
Allozyme & AA sequence data  
85% of variation within races  
15% of variation among races

Rosenberg et al. 2002. Microsatellites.  
93-95% of diversity with/in races  
5-7% among races

J. Z. Li et al. 2008. 938 individuals for 51 world poplns;  
Greater than > 640,000 SNP's.  
89.9% variation among individuals w/in populations,  
2.1% among populations within geographic regions,  
9.0% among major geographic regions.

From your previous discussion of *Ensatina* Ring Species

What are the consequences of isolation?

What are the consequences of secondary contact?

## Factors that Reduce or Prevent Gene Flow Between Species

- Pre-Mating, Pre-zygotic
- Post Mating, Pre-zygotic
- Post Mating, Post-zygotic

What determines the success of mating?

Factors that reduce gene flow

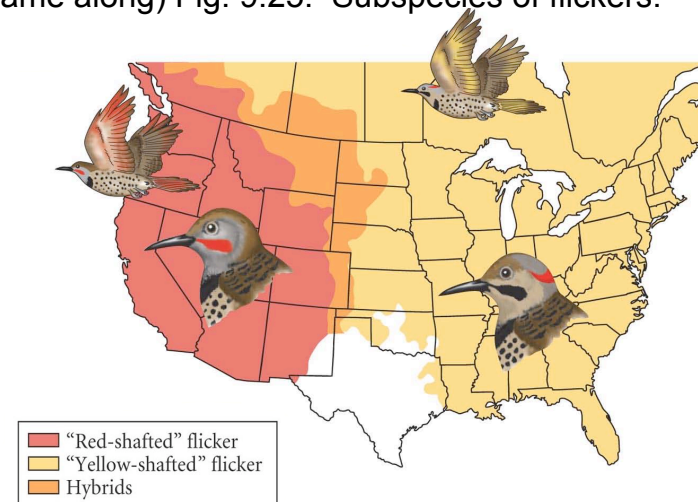
### I. Pre-Mating, Pre-Zygotic

- Adults do not meet: Spatial Isolation
  - Red- & yellow-shafted flickers
- Hawaiian *Banza* katydid species on different islands or volcanoes



Factors that reduce gene flow

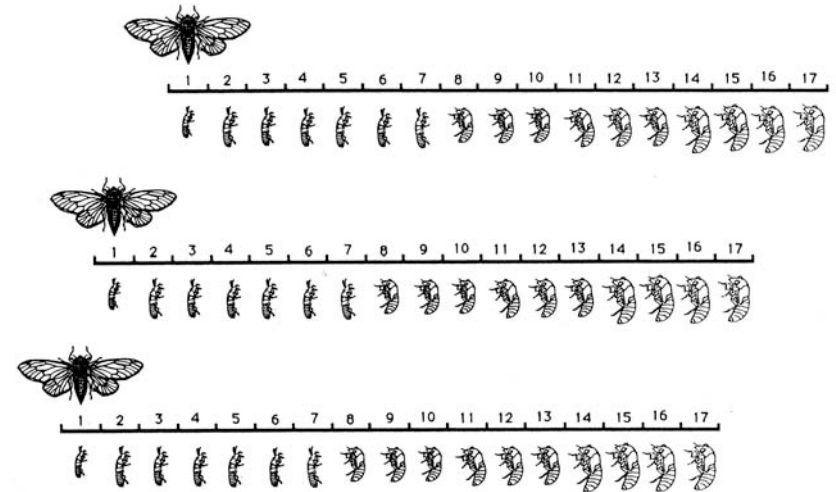
Adults do not meet (well, they didn't until people came along) Fig. 9.25. Subspecies of flickers.



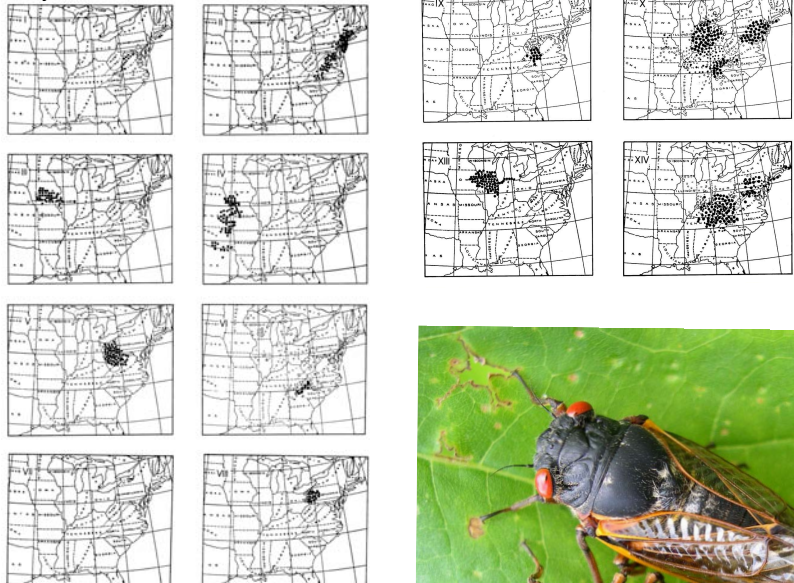
## I. Pre-Mating, Pre-Zygotic (cont.)

- Adults do not meet: Temporal Isolation
  - All 17-year cicada broods
  - *Gryllus veletis* & *Gryllus pennsylvanicus* crickets w/ spring vs. fall adults
  - Plants with anthers maturing at times different from stigmas.

Allochronic year classes of periodical cicadas called “broods”



17-year cicada broods



Factors that reduce gene flow

## I. Pre-Mating, Pre-Zygotic (cont.)

- Adults meet but don't mate
  - Visual- color, dances, light flashes
  - Auditory- substrate borne vibrations, air-borne vibrations
  - Chemical- pheromones

Factors that reduce gene flow

# I. Pre-Mating, Pre-Zygotic (cont.)

Color pattern, dances (push-ups)



*Anolis dulaps*



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[http://upload.wikimedia.org/wikipedia/commons/thumb/7/77e/Anolis\\_sagrei\\_%C3%A4te.JPG/300px-Anolis\\_sagrei\\_%C3%A4te.JPG](http://upload.wikimedia.org/wikipedia/commons/thumb/7/77e/Anolis_sagrei_%C3%A4te.JPG/300px-Anolis_sagrei_%C3%A4te.JPG)

Factors that reduce gene flow



Hawaii O'o (extinct)

Color pattern & dances



Birds of Paradise



<http://gallery.photo.net/photo/2271187-1g.jpg>  
[http://www.hpfineprints.com/images/LearGould-birds/Birds\\_of\\_Paradise1.jpg](http://www.hpfineprints.com/images/LearGould-birds/Birds_of_Paradise1.jpg)

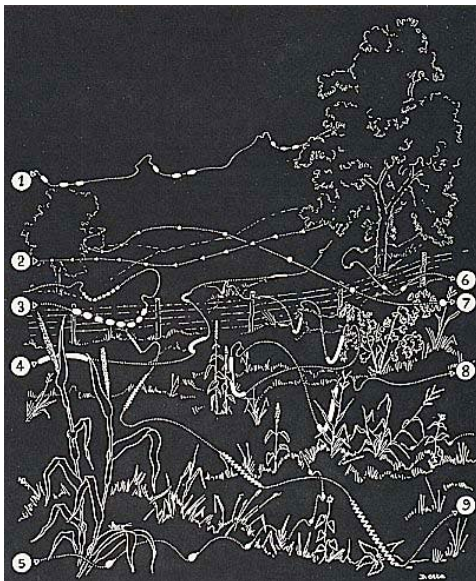
Factors that reduce gene flow

## Fireflies

Light flashes

Species specific timing & flight paths

Aggressive mimicry



<http://ase.tufts.edu/biology/Firefly/living.jpg> [http://www.sciencenewsforkids.org/articles/20060614/a1156\\_art962.jpg](http://www.sciencenewsforkids.org/articles/20060614/a1156_art962.jpg)

Factors that reduce gene flow

Hawaiian picture-wing *Drosophila* mating dance, + song and pheromones



Photo by William Mull

Factors that reduce gene flow

Near-field air pulsing: Diptera, *Drosophila*



Excitation of substrate by tymbals: Hemiptera, Auchenorrhyncha



Excitation of substrate by abdominal jerking: Neuroptera, *Chrysoperla*

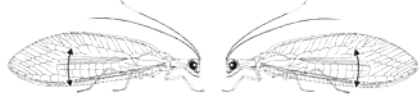
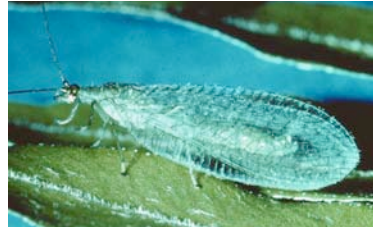


Illustration by Charles Henry

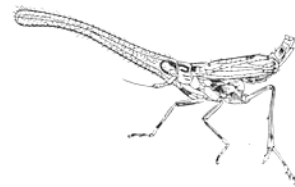
Substrate borne vibrations



Photos by William Mull

Factors that reduce gene flow

Hawaiian planthoppers



*Dictyophorodelphax mirabilis*

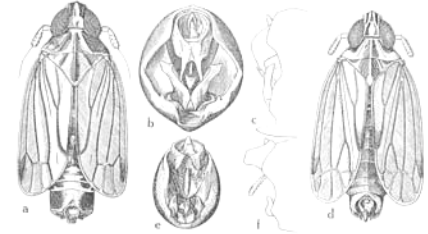


Figure 61—Holotypes of *Nesosydne*: a, *N. nubigena* Kirkaldy, male; b, rear view of pygochlore of a; c, the same in lateral outline; d, *N. nephelias* Kirkaldy, male

*Nesosydne nubigena* & *N. nephelias*



Sounds from Hannelore Hoch & Manfred Asche

Illustrations from Zimmerman "Insects of Hawaii"

Factors that reduce gene flow

Audible songs

Cicadas

The NZ clicking cicada:

*Amphipsalta zelandica*

Wing clicks

Tymbal vibrations

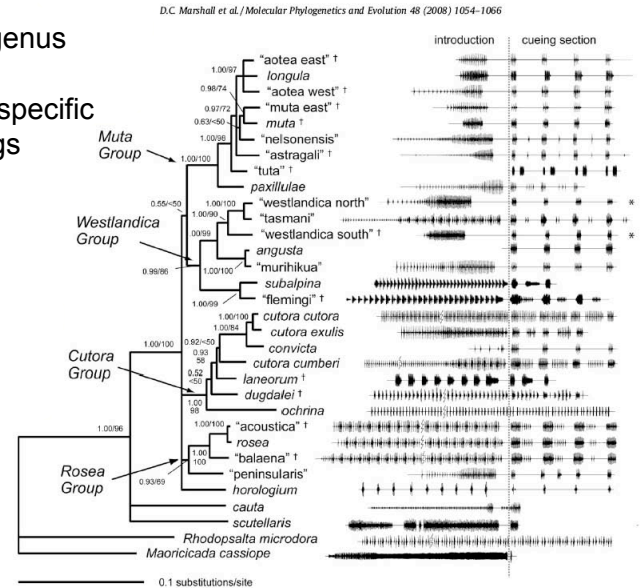


Factors that reduce gene flow

NZ cicada genus

*Kikihia*

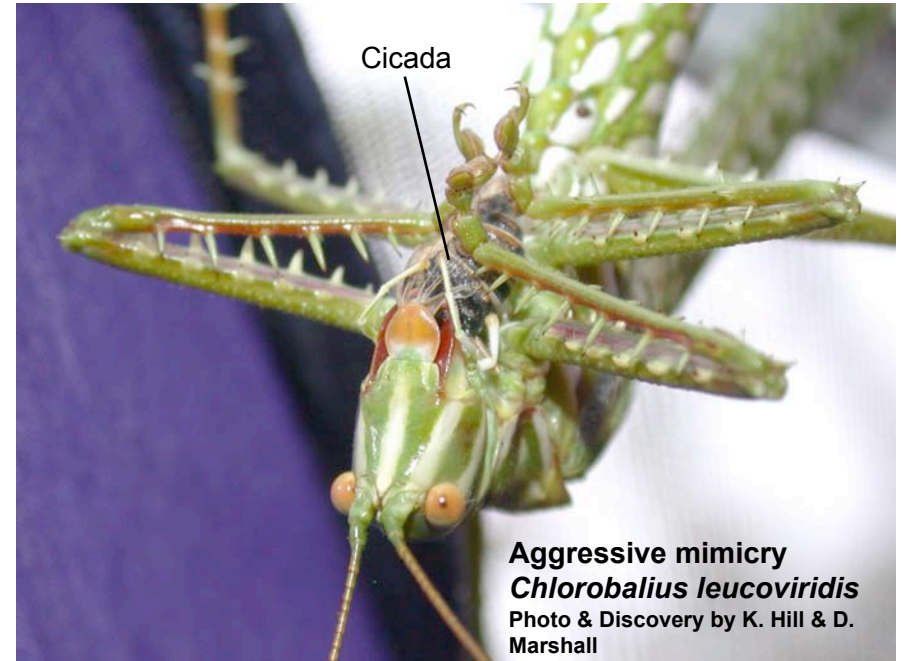
30 species-specific mating songs



In NZ cicadas, females respond to male song by wing flicking to denote receptivity:



Dan Vanderpool demonstrates w/ *Maoricicada campbelli*



**Aggressive mimicry**  
***Chlorobalius leucoviridis***  
Photo & Discovery by K. Hill & D. Marshall

Factors that reduce gene flow

## II. Post-Mating, Pre-Zygotic

- Lock and Key Hypothesis
- Sexual selection by female choice
- Gametic failure

*Phyllophaga* May beetles

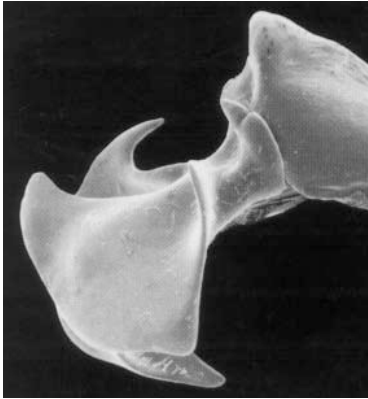
Photos by Maxi Polihronakis



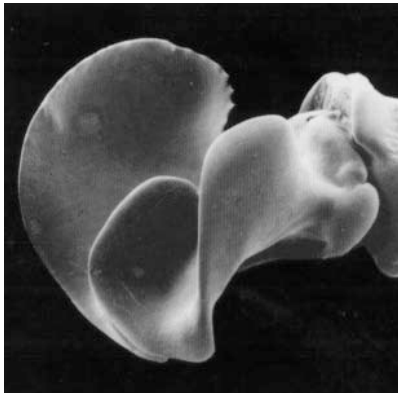
Factors that reduce gene flow

## Male genitalia of *Phyllophaga* sp.

*P. infidelis*- Lateral view

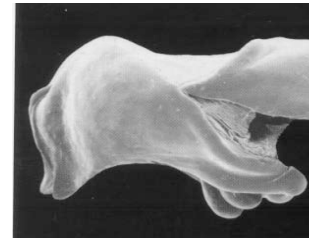


*P. knochii*- Lateral view

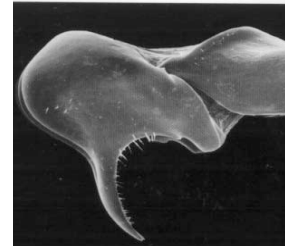


Photos by Maxi Polihronakis

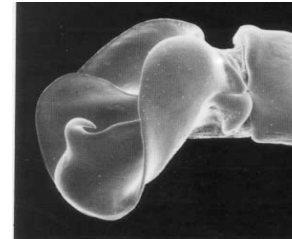
*P. glaberrima*- lateral view



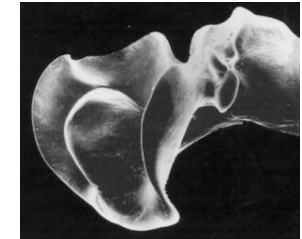
*P. gracilis*- lateral View



*P. hornii*- lateral view



*P. ilicis*- lateral view



Photos by Maxi Polihronakis

## Stages at which gametes can fail

- 1) Attraction of sperm to egg
- 2) Induction of sperm acrosome by egg surface proteins.
- 3) Adhesion of sperm to egg envelope (abalone & sea urchin)
- 4) Penetration of egg envelope by sperm (mammals)
- 5) Fusion of sperm and egg cell membranes
- 6) Fusion of sperm and egg nuclei

## Lysin in abalone

Lee & Vacquier (1992) Biological Bulletin.182:97-104. Sequenced 7 species of abalone.

- Detected positive selection at AA level in active site of Lysin protein
- McDonald Kreitman test:

### III. Post-Mating, Post-Zygotic

- A. Fertilization occurs, embryo dies
- B. Hybrids are produced but are of low fitness
- C. Adult offspring are viable but sterile or partially sterile.

Question: How does fertilization ability differ in hybrid crosses between close vs distant species?

- Breeds of dogs?
- Wolf vs. dog or coyote?
- Dog vs. cat?

Factors that reduce gene flow

*R. pipiens* x *R. sylvatica*



Hybrid embryo stops developing at early gastrula stage

<http://www.werc.usgs.gov/fieldguide/images/rapi1.jpg> <http://www.cortland.edu/herp/keys/images/frogs/rsylvalg.jpg>

Factors that reduce gene flow

donkey x horse = sterile mule



<http://www.hedweb.com/animimag/donkey.jpg> <http://animals.nationalgeographic.com/staticfiles/NGS/Shared/StaticFiles/animals/images/primary/przewalskis-horse.jpg> [http://extras.mnginteractive.com/live/media/site36/2007/0725/20070725\\_20070726\\_A1\\_CD26MULE-p1.JPG](http://extras.mnginteractive.com/live/media/site36/2007/0725/20070725_20070726_A1_CD26MULE-p1.JPG)

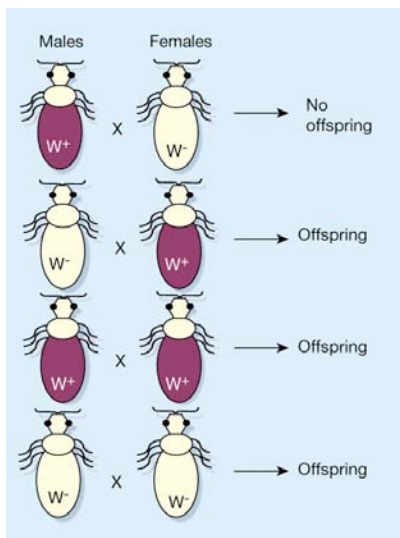
## Reasons for Post-mating incompatibility with increasing genetic distance:

- a) allele combinations are not ideal (breakdown of coadapted allele complexes)
- b) genes or gene products don't work well together (mtDNA x nuc DNA incompatibility)
- c) chromosomes contain translocations, inversions, or differ in number. Can't pair properly.

## Haldane's Rule

JBS Haldane

- In Humans and *Drosophila*, males are heterogametic, but in other organisms, e.g., most amphibians, birds, butterflies and reptiles, the female is heterogametic.
- when sterility is confined to one sex, it will always be the heterogametic sex.
- Partial explanation: when recessive deleterious alleles causing hybrid problems are on sex chromosomes they are expressed in heterogametic hybrids but not in homogametic hybrids. Orr, A. 1997. Ann. Rev. Ecol. Syst.



## Special Case: Parasitic Sterility

### *Wolbachia*

Infect 15-20 % of all insect species, also found in spiders, isopods, and nematodes

Infection leads to sterility in some crosses