Lecture 25. Speciation Mechanisms (cont.); Hybridization

EEB 2245, C. Simon

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Last time …

- Speciation mechanisms (continued)
  - *Magicicada* case study (allochronic speciation and reproductive character displacement- disruptive selection)
  - Divergence with gene flow
  - Parapatric speciation
    - Ecotone- adaptive genes w hitchhiking male and female choice genes
    - Dobzhansky-Mueller interactions (certain allele combinations cause sterility).
  - Sympatric speciation (host races)

This time …

Speciation mechanisms (cont).

- The link btw character displacement and disruptive selection.
- Sympatric speciation (host races)
- Chromosomal speciation
- Parallel speciation
- Hybrid speciation w/o polyploidy (galapagos finches)
- Hybrid speciation w/ polyploidy (sunflowers)
- The importance of co-adapted allele complexes.

Remember from Lecture 19…

Three major categories of natural selection

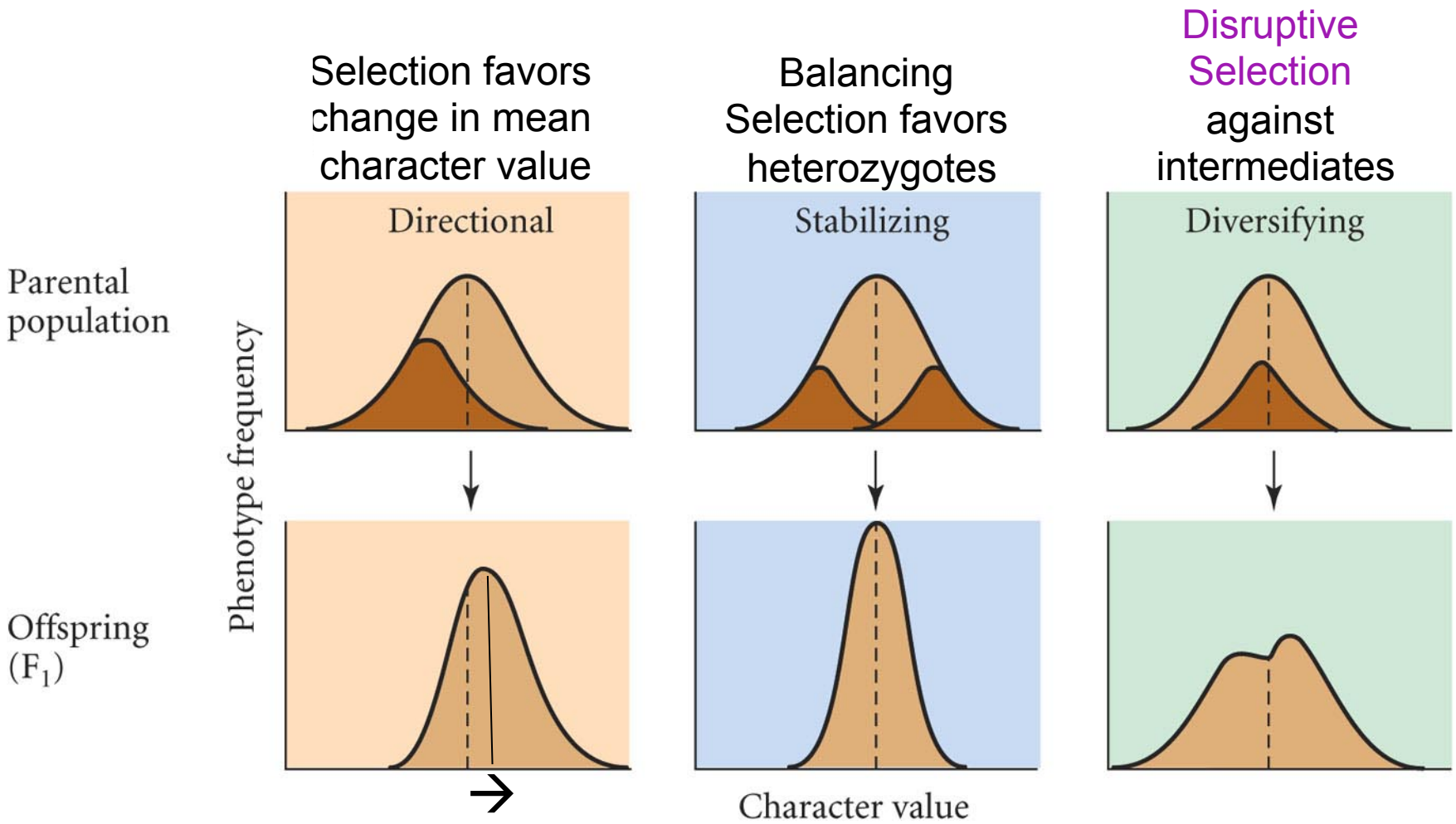


Fig. 12.1 Futuyma. Dark brown areas = lower fitness, selected against

Diversifying or Disruptive Selection against intermediates (heterozygotes, hybrids)

Disruptive

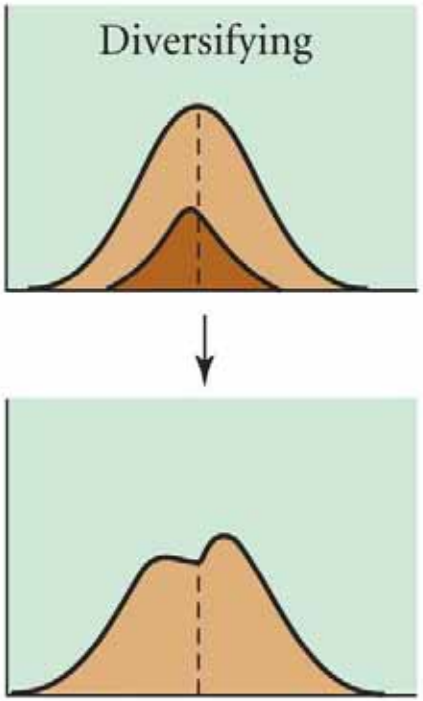


Fig. 12.1 Futuyma. 3e. Dark brown areas = lower fitness; selected against

Leads to character displacement following secondary contact and requires…

1) Some variation in reproductive signal
2) Lowered fitness of individuals that engage in courtship with individuals from other population either because a) fewer offspring survive & reproduce, or b) even if mating does not go to completion, fewer total offspring b/c hybrid courtships waste limited mating time.

Thus, selection favors individuals best able to distinguish individuals from their own population.

From last time…

Sympatric Speciation

- Difficult to envision since sympatric populations overlap!
- Need extreme assortative mating and disruptive selection to eliminate any heterozygotes for mating genes (as in parapatric speciation)
- Current day overlap is not evidence for sympatric speciation. Most likely secondary contact.

Not discussed last time…

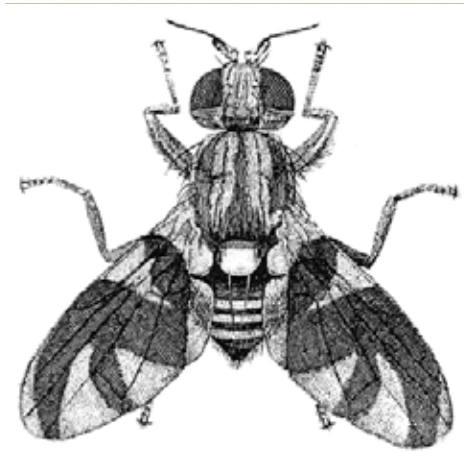
Sympatric Speciation

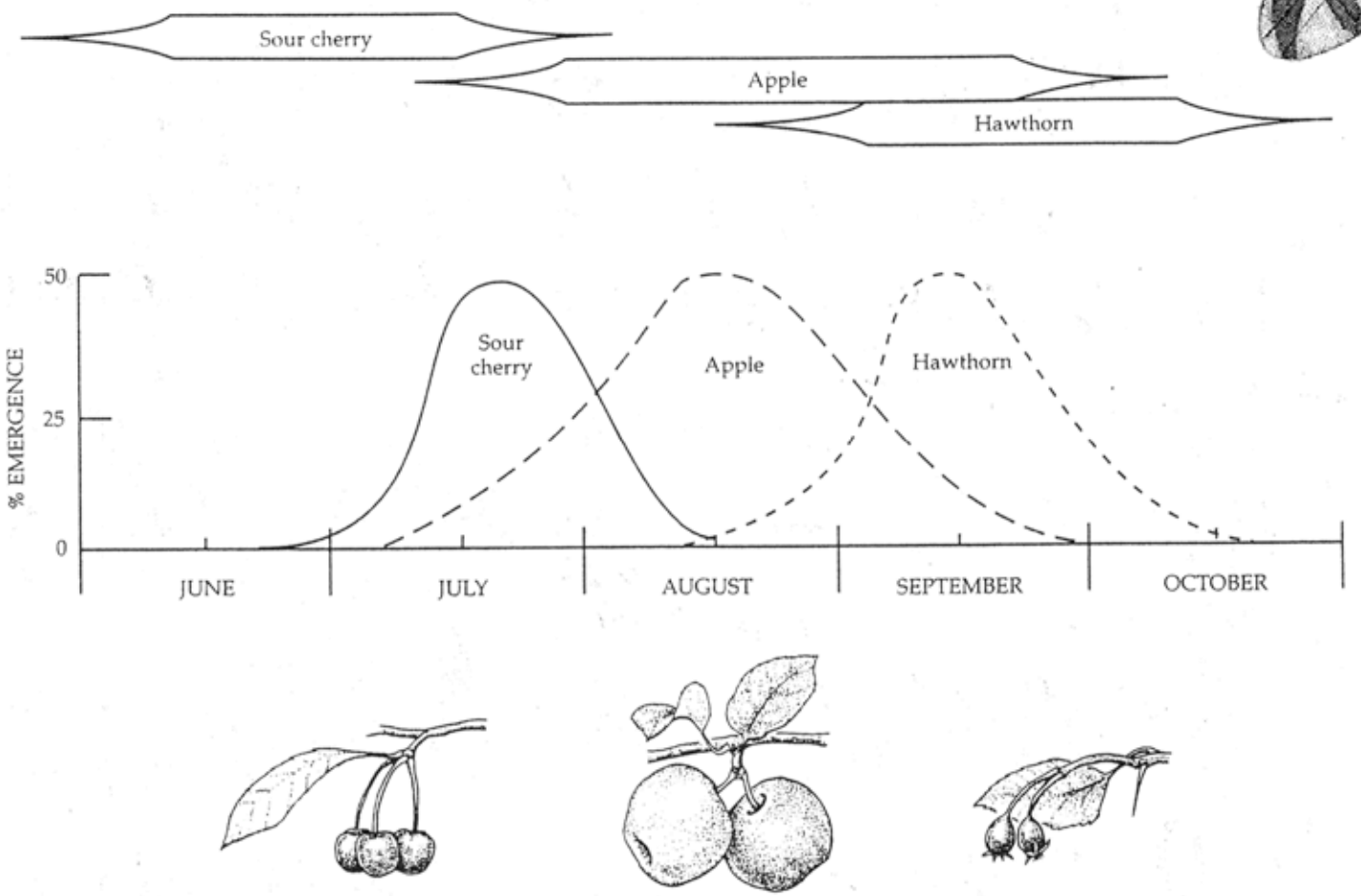
Best examples involve "host race speciation"

- True fruit flies (family Tephritidae) of the genus *Rhagoletis*. On native hawthorn vs. introduced cherry vs. introduced apple.
- *Enchenopa* Treehoppers. Distributed from Panama to S. Canada. Host races on seven genera of NE forest plants: walnut, black locust, bittersweet vine, viburnum, redbud, tulip tree and Hoptree.

Micro-allopatric speciation? Allochrony involved.

Host races of *Rhagoletis pomenela*





http://www.cals.ncsu.edu/course/ent425/text18/applemaggot.jpg

Enchenopa tree hoppers: Tom Wood, U. Delaware

http://farm3.static.flickr.com/2156/2535390394_4b8d20ede2.jpg?v=0

Criteria for defining host races

Drès and Mallet. 2002 Phil. Trans. R. Soc. Lond. B

1a. Use different host taxa in the wild.

1b. Individuals exhibit fidelity to particular hosts.

2. Coexist in sympatry w/ other races (at least in part)

3a. Are genetically differentiated at more than one locus.

3b. More genetically similar to distant populations on the same host than to sympatric populations on different hosts.

4a. Display a correlation between host choice and mate choice.

4b. Can survive in the face of gene flow.

5a. Have higher fitness on natal than alternative hosts; and

5b. Produce hybrids that are less fit than parental forms.

Spatial speciation is not instantaneous.
Chromosomal speciation can be.

Chromosomal Speciation

- Can be instantaneous
- Involving chromosomal rearrangements
- Involving polyploidy (*Hyla* tree frogs)

Chromosomal Speciation

- Involving Polyploidy (but no hybridization)

Example: eastern North American hylid tree frogs
Ptacek, Gerhardt, and Sage. 1994. Evolution 48(3):898-908; Holloway, Cannatella, Gerhardt, & Hillis. 2010. Amer. Natur. 167 (4): E 88- E 101

•*Hyla chrysoscelis* is diploid. Found in east & central west.

•*Hyla versicolor* is a tetraploid. Larger body, larger cell size, mating song slower pulse rate. Three disjunct popnls.

•Tetraploids cannot mate with diploids.

•Cyt. B. phylogeny shows multiple, independent origins of *H. versicolor*! Non-monophyletic.

Chromosomal speciation with polyploidy

Hyla chrysoscelis 2N

Hyla versicolor 4N

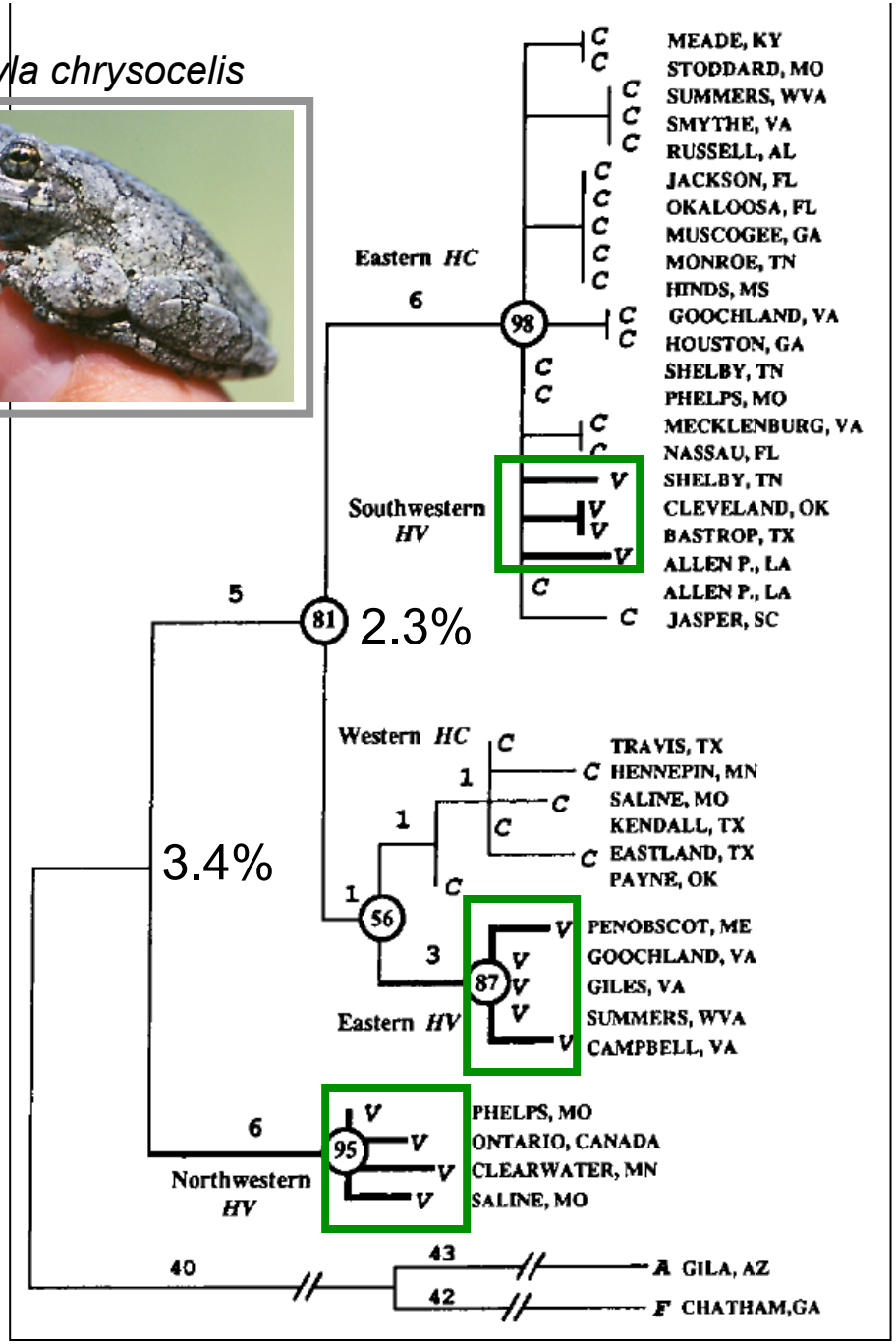
polyploid

Polyphyletic species

Parallel Speciation

Hyla versicolor

Hyla chrysocelis



http://www.marietta.edu/~biol/biomes/images/deciduous/hylavers.jpg; http://www.biology.duke.edu/dnhs/pics/Hylachry2.jpg

Species are often viewed as “real” biological entities while higher taxa are correctly recognized as artificial human constructs. Why?

Definition of higher taxa (genera, families, orders, etc.) is inconsistent across the tree of life.

No specific taxon age, nor number of included descendant taxa.
Only defined by morphological gaps

Why are species different?

How would you view *H. versicolor* under the biological species concept vs. phylogenetic species concept?

H. chrysoscelis?

Parallel Speciation- the production of reproductively compatible groups of populations (a species) where various populations arise independently from an ancestral population multiple times.

Non-monophyletic (= polyphyletic)

Can be due to characters that confer both reproductive isolation and ecological adaptation (as in host races)

Or isolation can be a biproduct of similar adaptation of multiple independent populations faced with similar new environments (Termed “Ecological Speciation”)

Other examples of parallel speciation

http://www.alaskafishingak.com/salmon_types/sockeye/sockeye.htm

Marine sockeye salmon vs. freshwater Kokanee: Freshwater morph formed many times independently; different reproductive timing.

(Waples et al. 2004. Evolution)

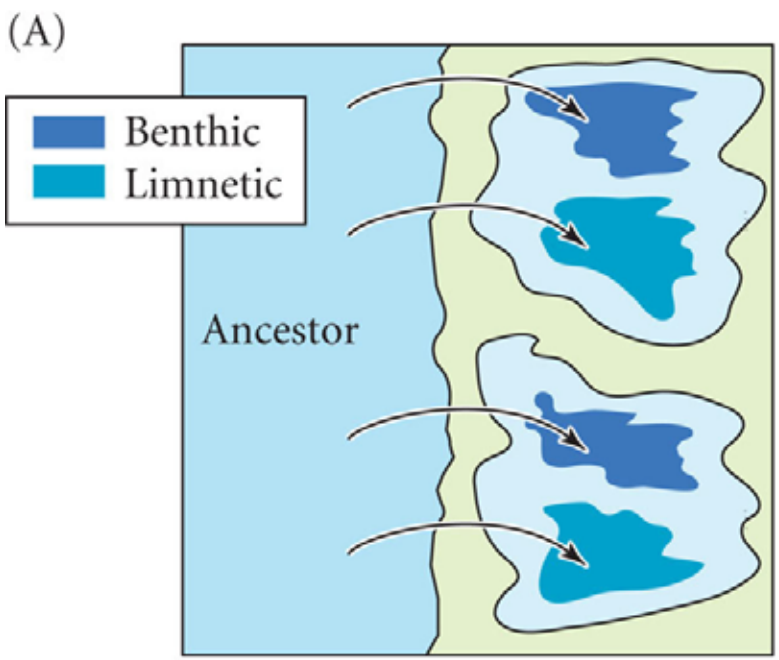
http://evolution.unibas.ch/salzburger/team/dberner/?view=printable

Stickleback fish: benthic & limnetic forms arose multiple times independently; competitive character displacement.

(Schluter 2001. TREE)

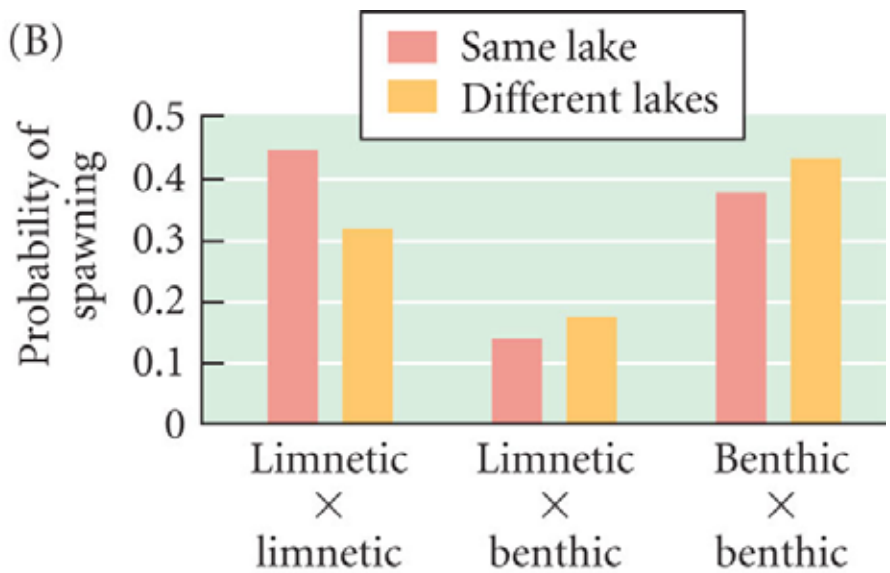
Parallel speciation in sticklebacks in British Columbia

Colonization scenario

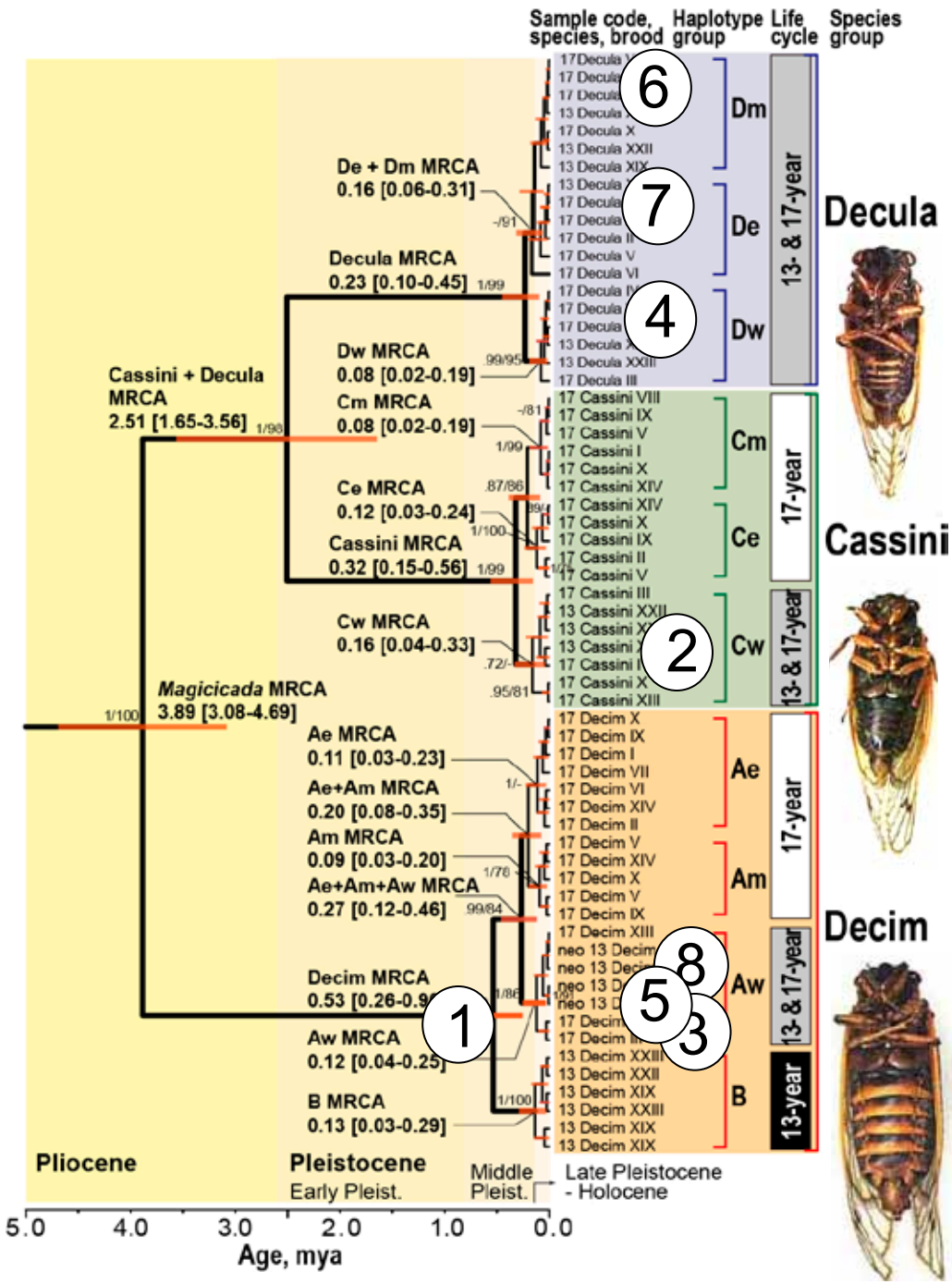


Futuyma 3e Fig. 18.9

Mating Success



Positive assortative mating most successful



Eight instances of 13-17-year splits (species formation)

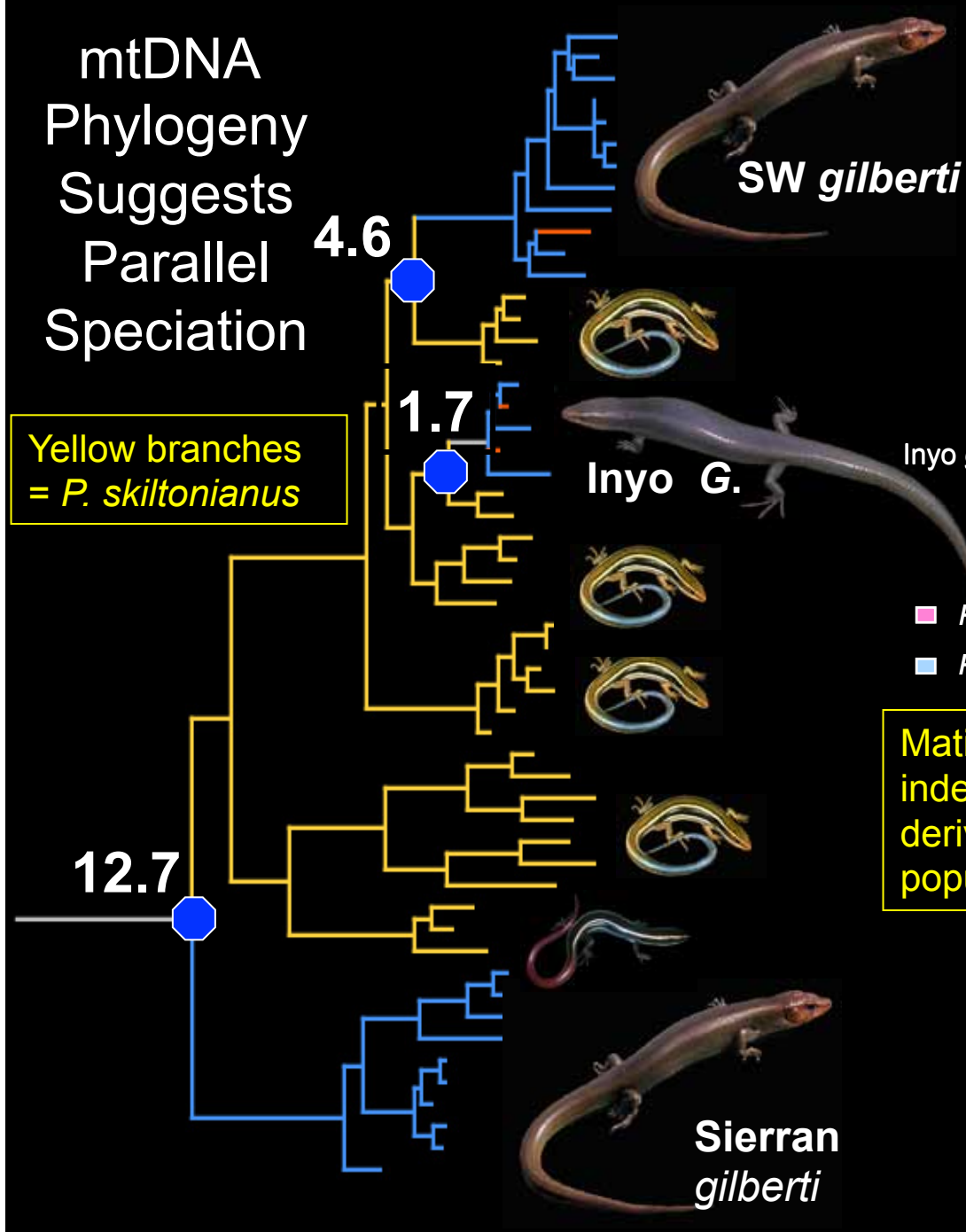
Three independent origins of 13-yr in the Decula species group.

One 13-yr origin nested inside the Cassini species group (paraphyletic).

>Two independent origins of 13-yr in the Decim species group + possible new 17-yr.

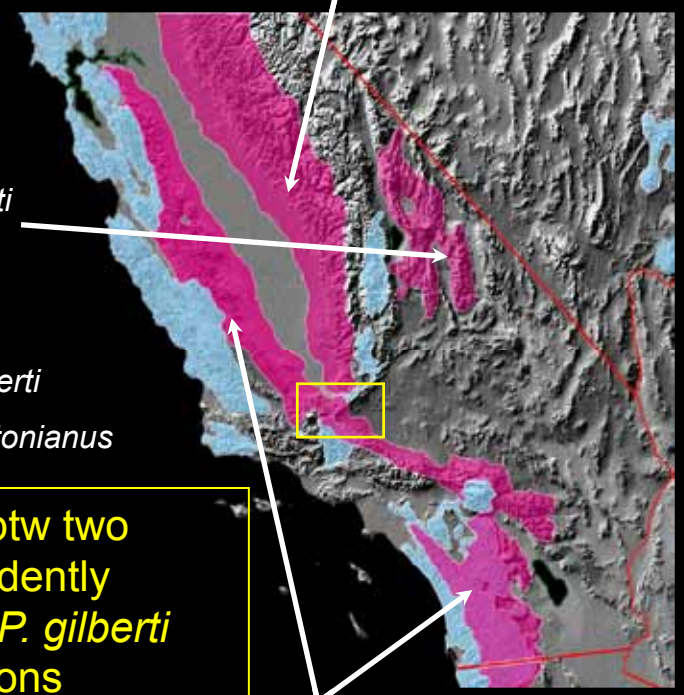
Ecological trigger: warmer climate allows faster (13-yr) development in south and require longer development time in north (17-yr).

mtDNA Phylogeny Suggests Parallel Speciation



Yellow branches = *P. skiltonianus*

Plestiodon skinks

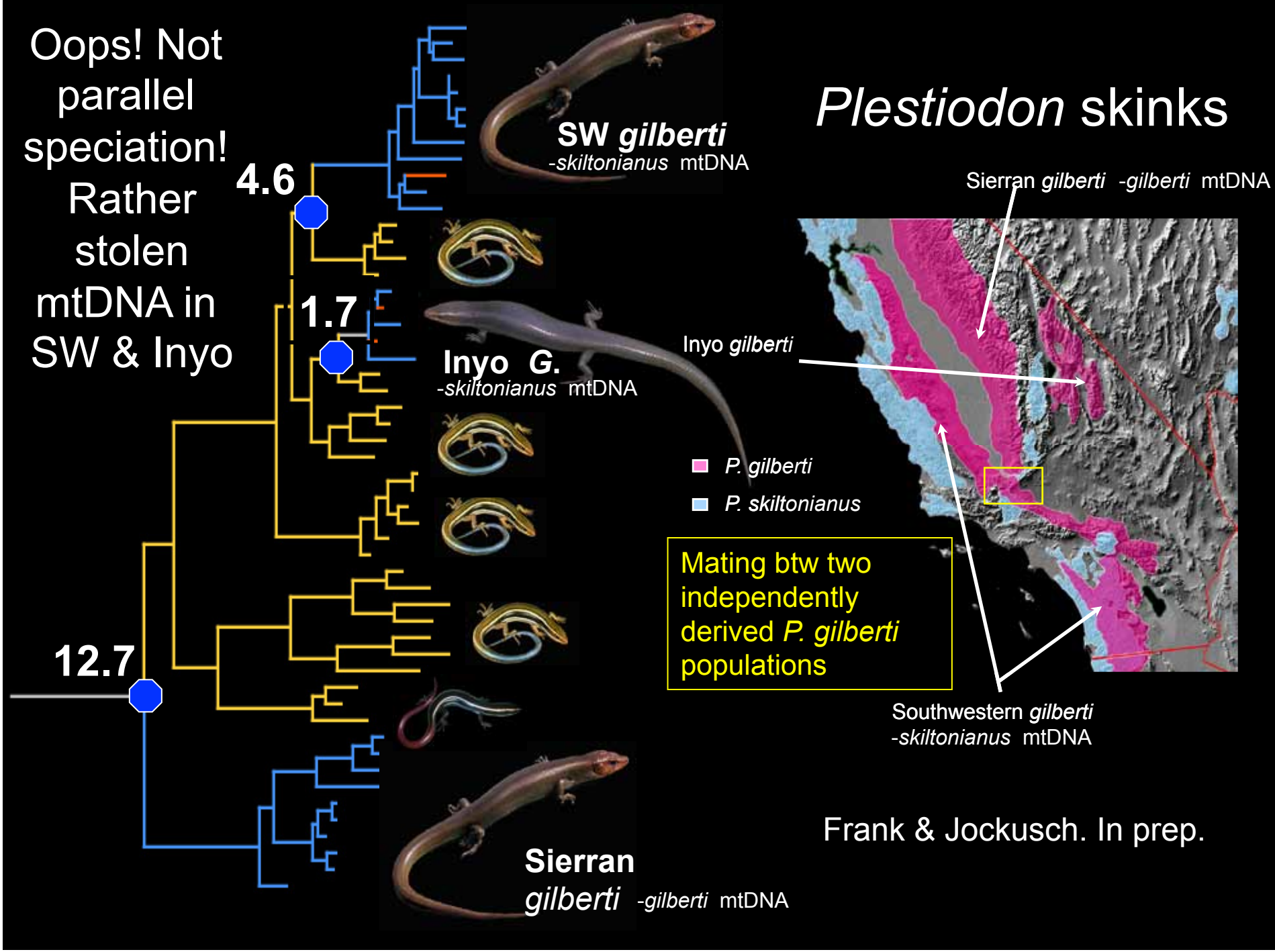


Mating btw two independently derived *P. gilberti* populations

Richmond & Jockusch. 2007. Proc. Roy. Soc. B.

Plestiodon skinks

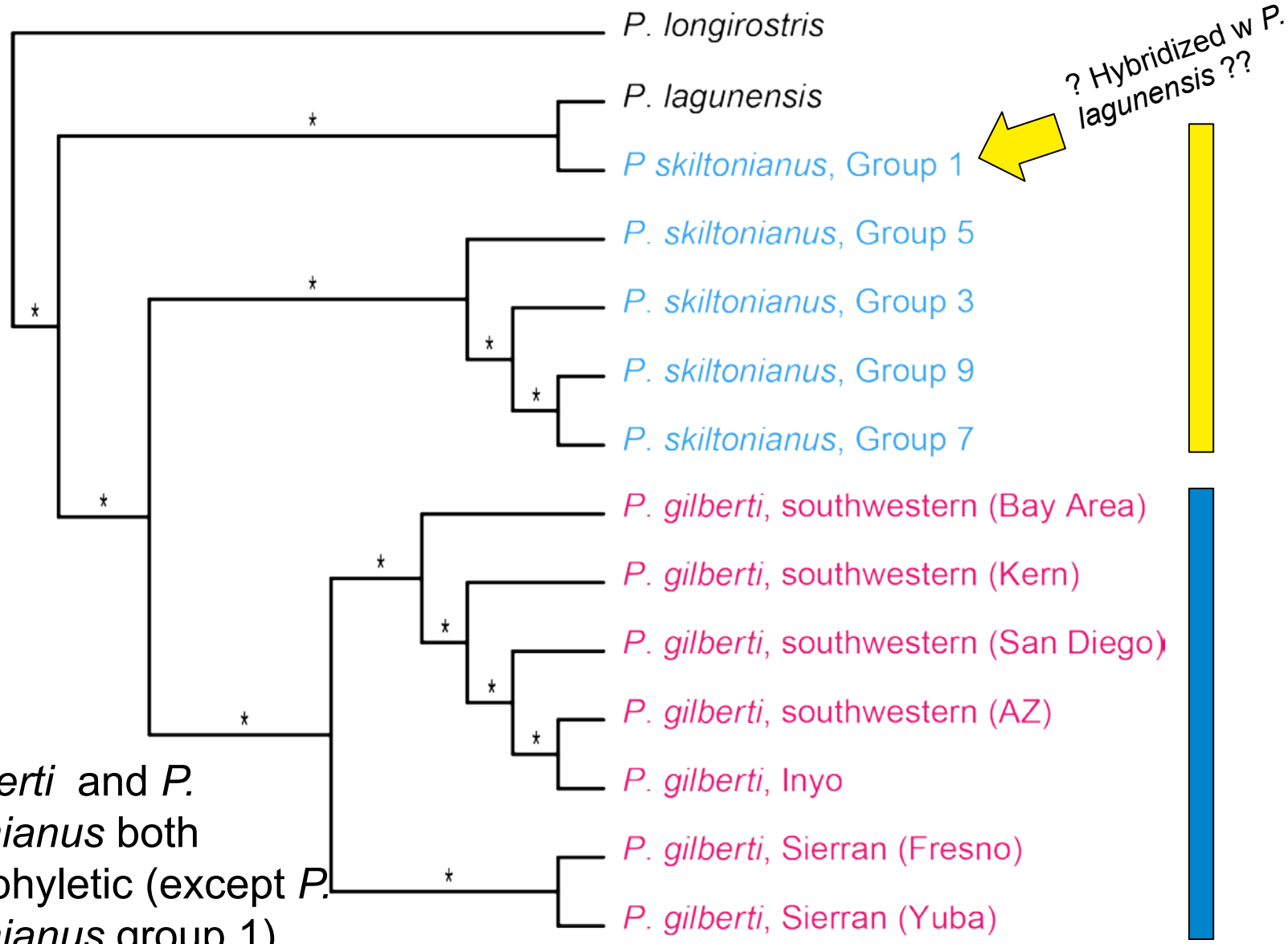
Oops! Not parallel speciation! Rather stolen mtDNA in SW & Inyo



Mating btw two independently derived *P. gilberti* populations

Frank & Jockusch. In prep.

Frank & Jockusch. Nuclear Genomic *Plestiodon* Phylogeny



P. gilberti and *P. skiltonianus* both monophyletic (except *P. skiltonianus* group 1)

The end