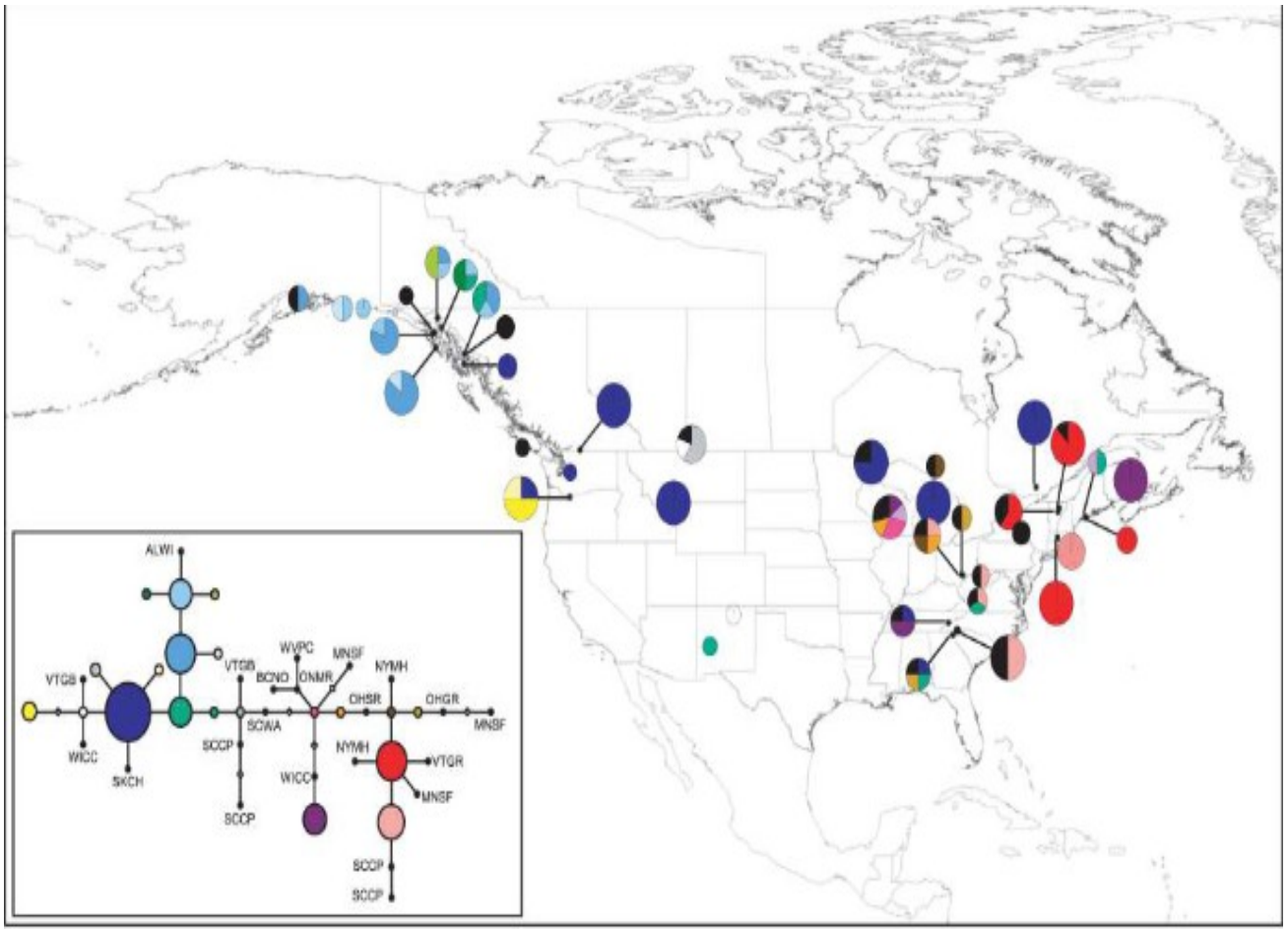
CORSO DI BOTANICA SISTEMATICA

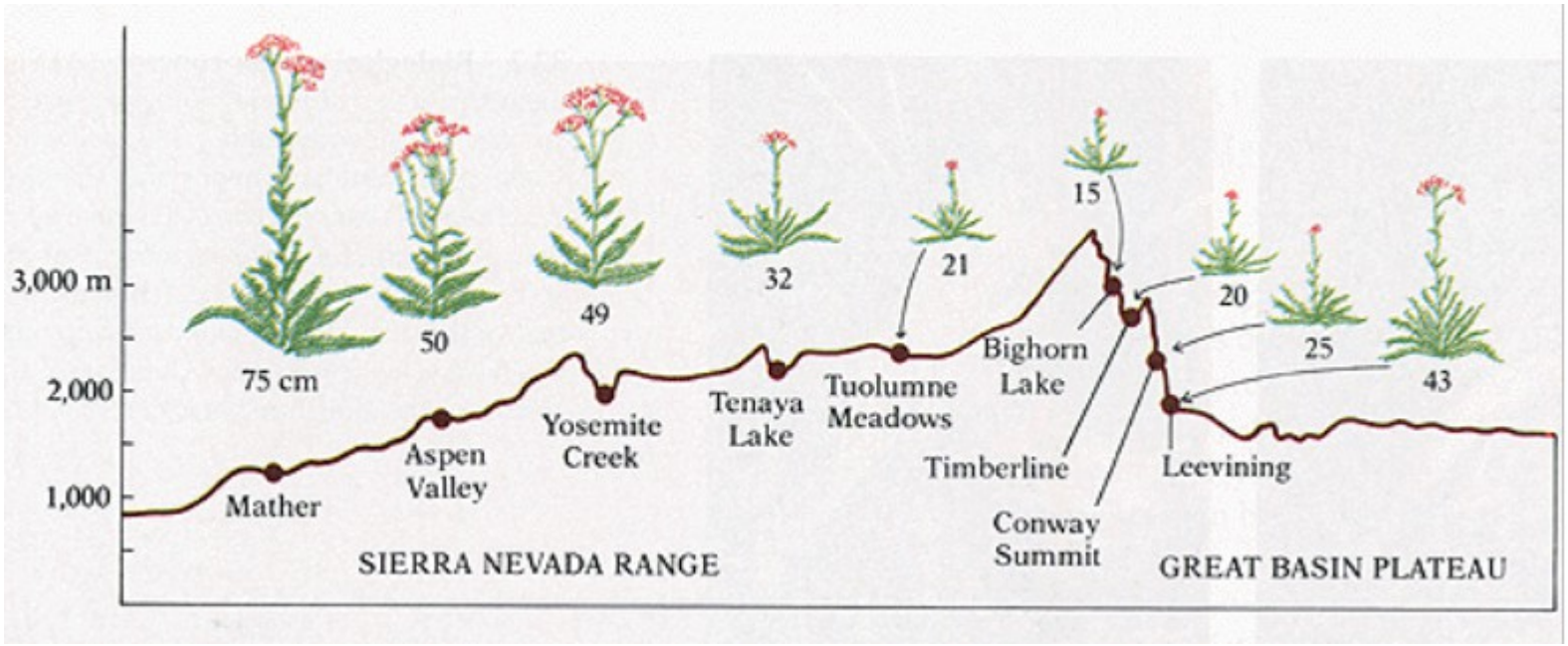
LEZIONE 43

Meccanismi di evoluzione e speciazione

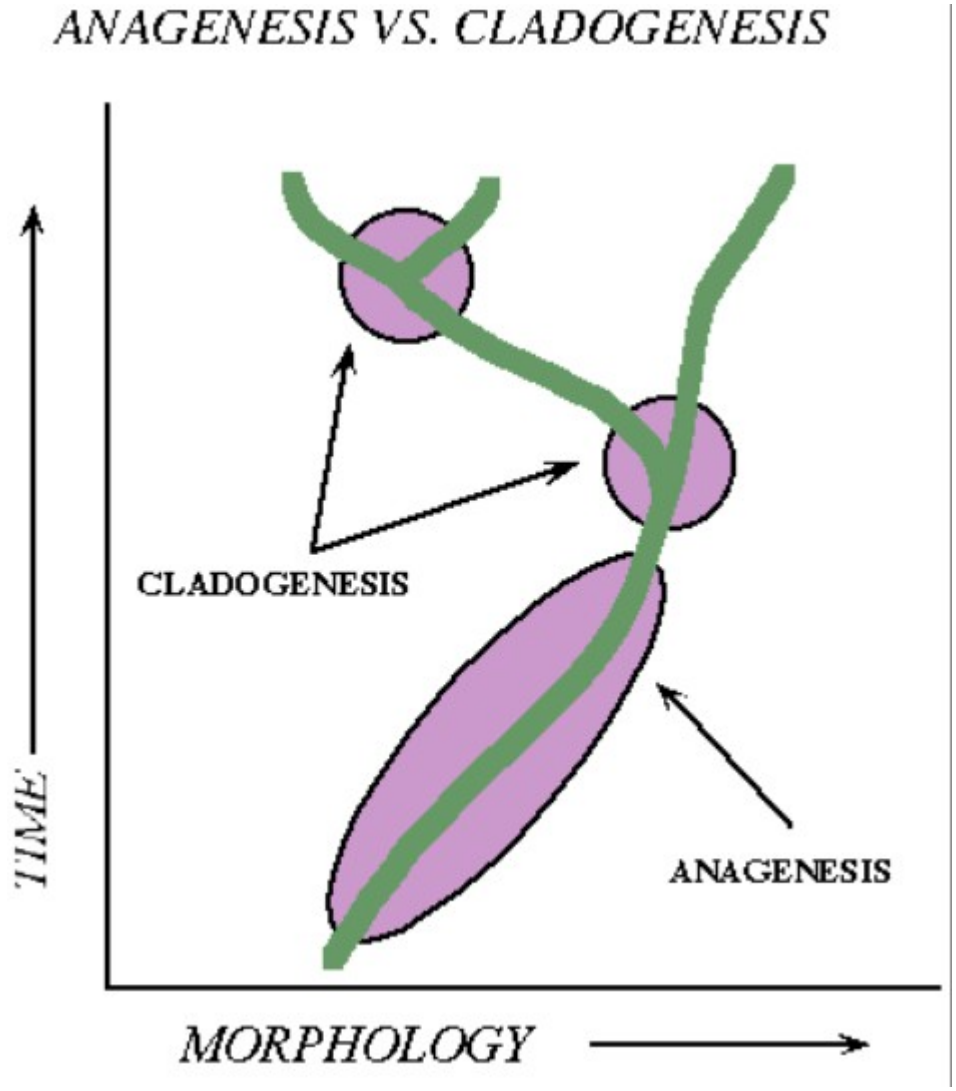
Variazione genetica entro una popolazione



Variazione genetica entro una specie (aplotipi di *Monotropa hypopitys* in N America)

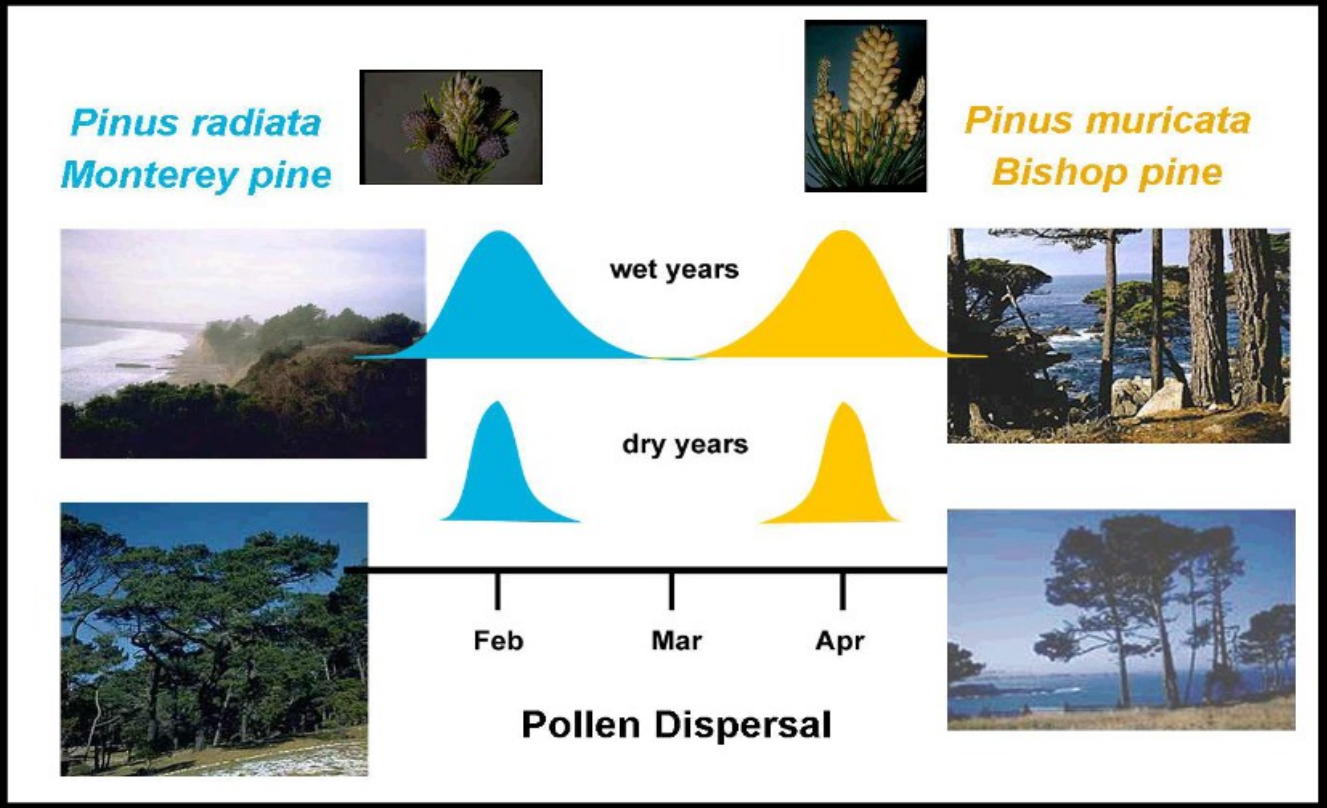


Variazione fenotipica clinale di *Achillea lanulosa* nella Sierra Nevada


ANAGENESIS VS. CLADOGENESIS
CLADOGENESIS
ANAGENESIS
TIME
MORPHOLOGY

Reproductive Isolation

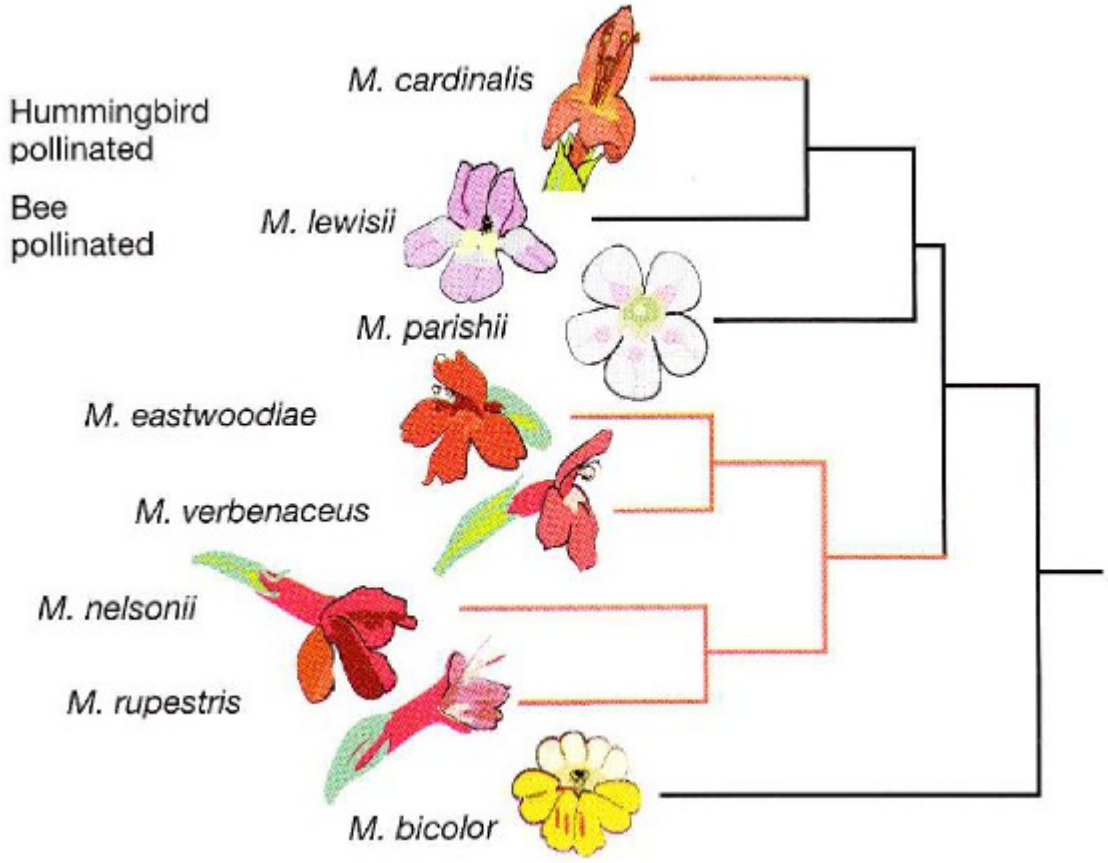
Seasonal or temporal isolation - different times of reproduction



Reproductive Isolation

Mechanical isolation - variation in floral form prevents interspecies pollen movement

- pollen placement or floral form in pseudocopulatory orchids



Isolamento riproduttivo in due specie di *Mimulus* dovuto a diversi impollinatori

Mimulus cardinalis

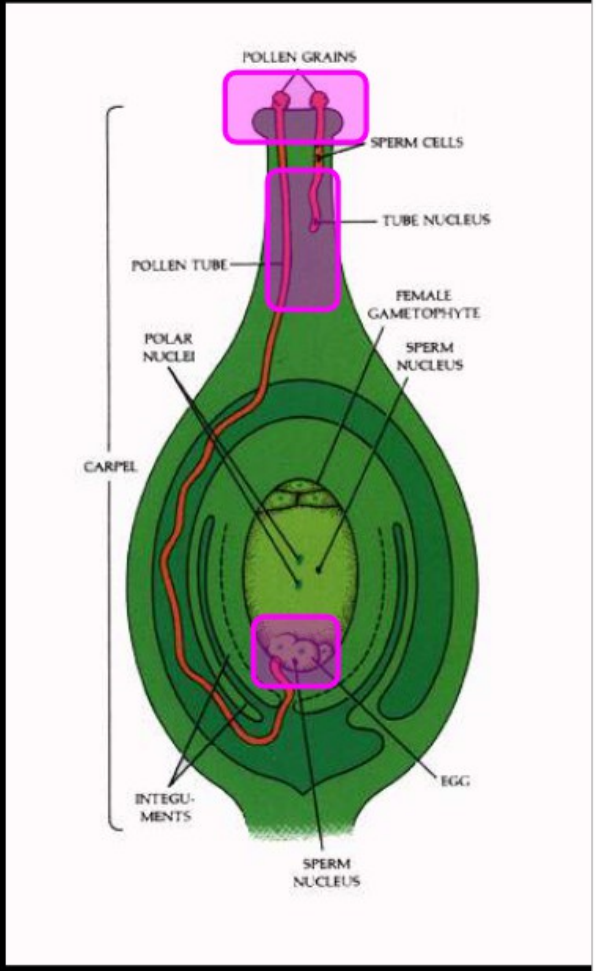
- few genes generated the floral differences that maintain reproductive isolation - however, species can readily hybridize in the greenhouse

Mimulus lewisii

Reproductive Isolation

Gametic incompatability - at three levels in *Heliconia*

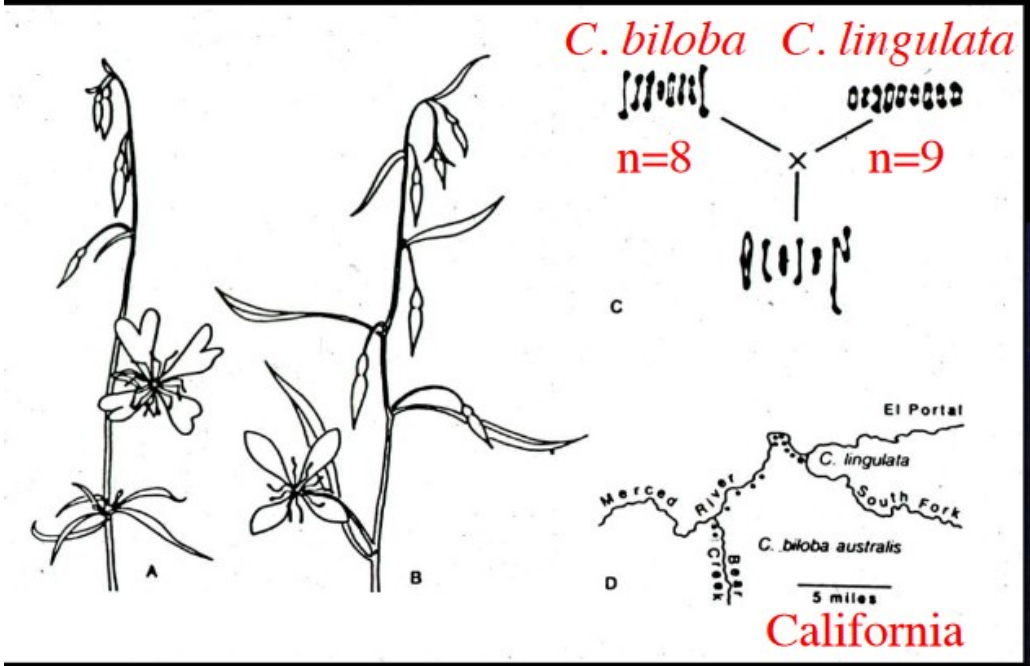
- pollen - stigma: no recognition (lipids)
- pollen tube - style: pollen tube rupture (arabinogalactan protein growth regulation)
- gamete - gamete: sperm-egg rejection



Reproductive Isolation

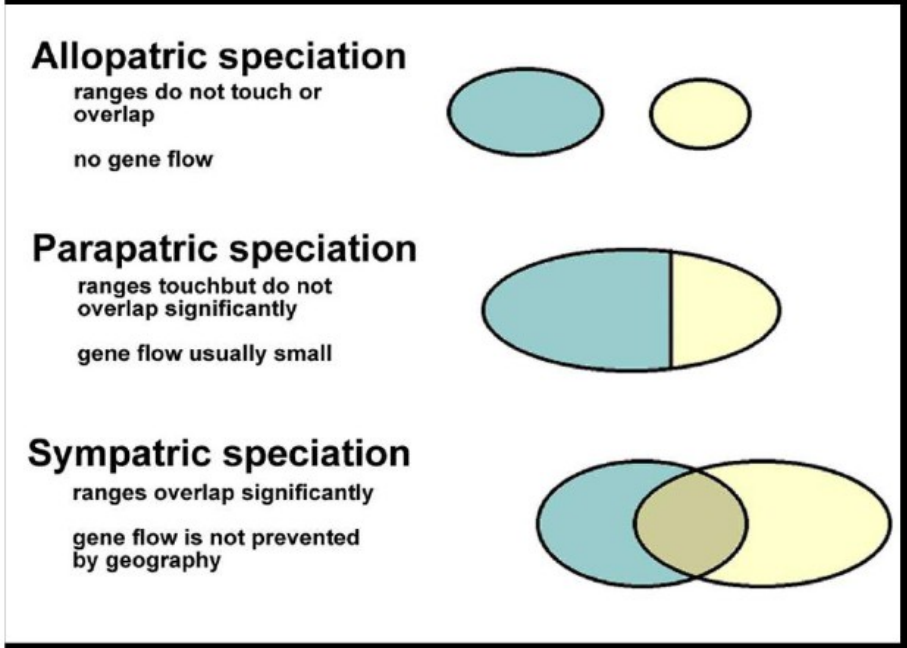
Hybrid sterility - F_1 sterility

- *Clarkia biloba* & *C. lingulata* - sister species, but differ in chromosome number (n=8 vs. n=9) - intersterile



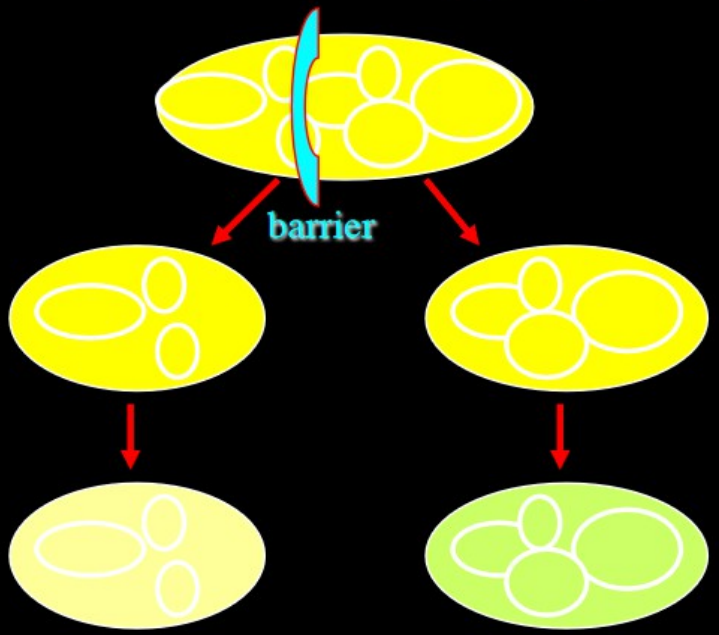
Models of Speciation

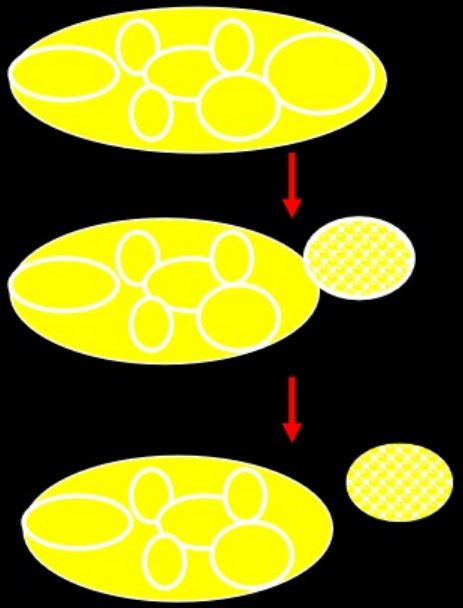
Speciation or Cladogenesis - most models or processes of speciation are based on biogeography (*'patry'* - homeland)



- geographical
- catastrophic or quantum – will not talk about
- diploid hybrid (homoploid)
- polyploid

Geographic Speciation

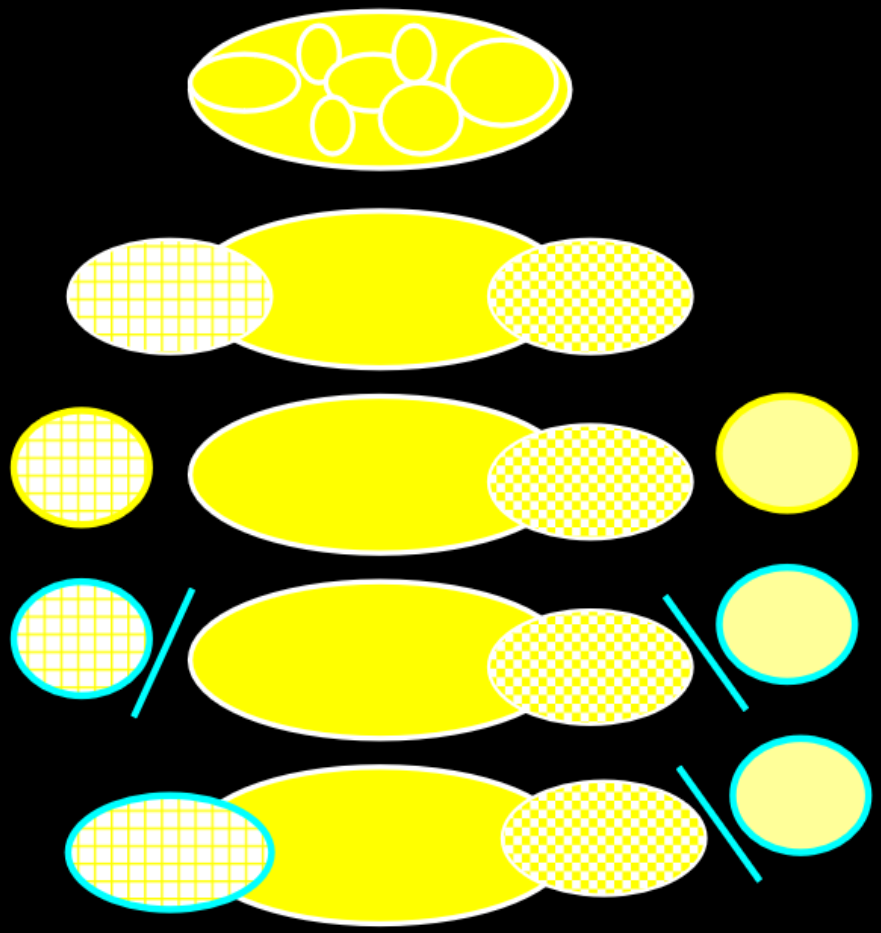




- 'dumb-bell' model: ancestral species forms two new species by division

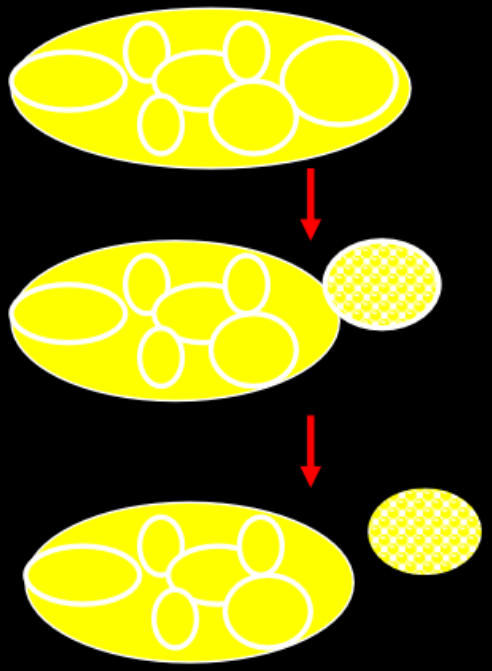
- peripheral isolate model: one new species forms at edge of retained ancestral species

Geographic Speciation



- freely interbreeding series of populations
- races form in response to n.s. and environmental variation
- differentiation and migration lead to geographically isolated races or subspecies
- reproductive isolation forms within or between subspecies and races
- range expansion allows new species to co-exist

Geographic Speciation

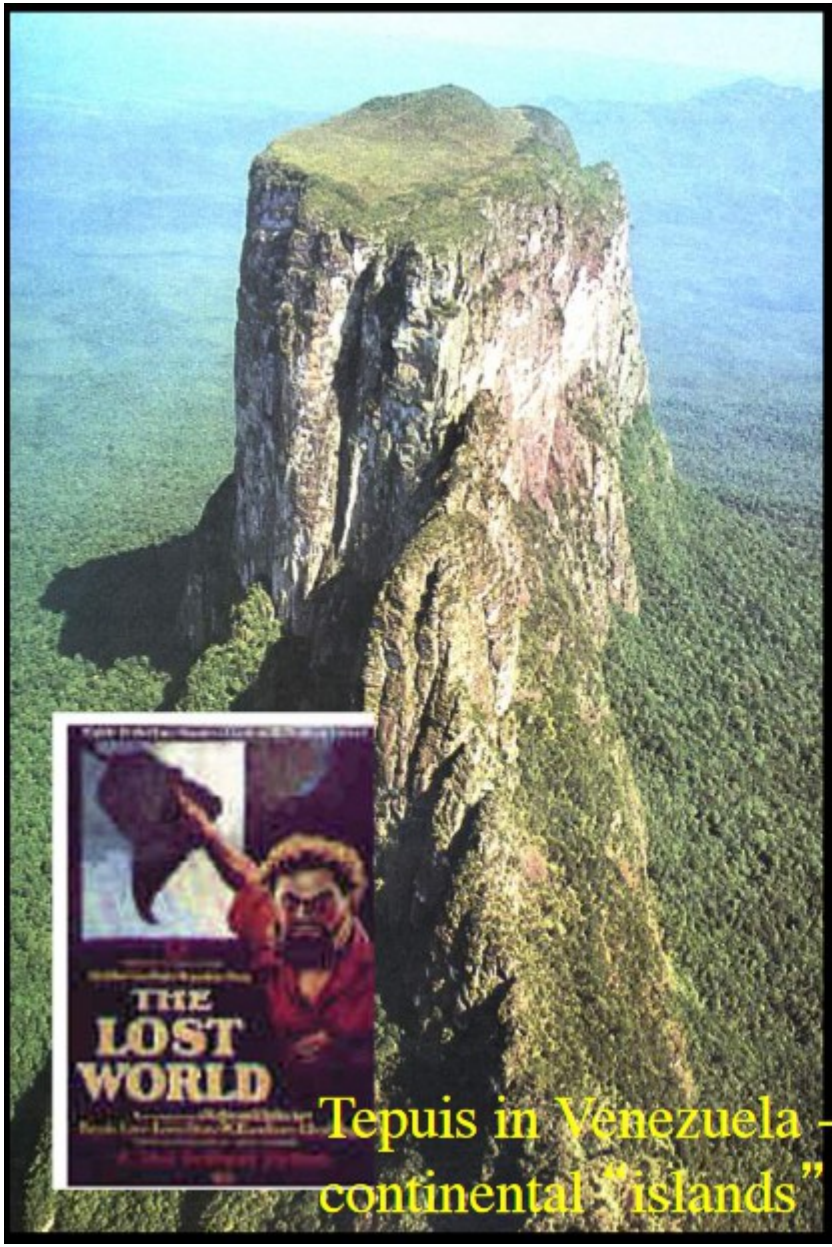


• peripheral isolate model: new species forms at edge of retained ancestral species

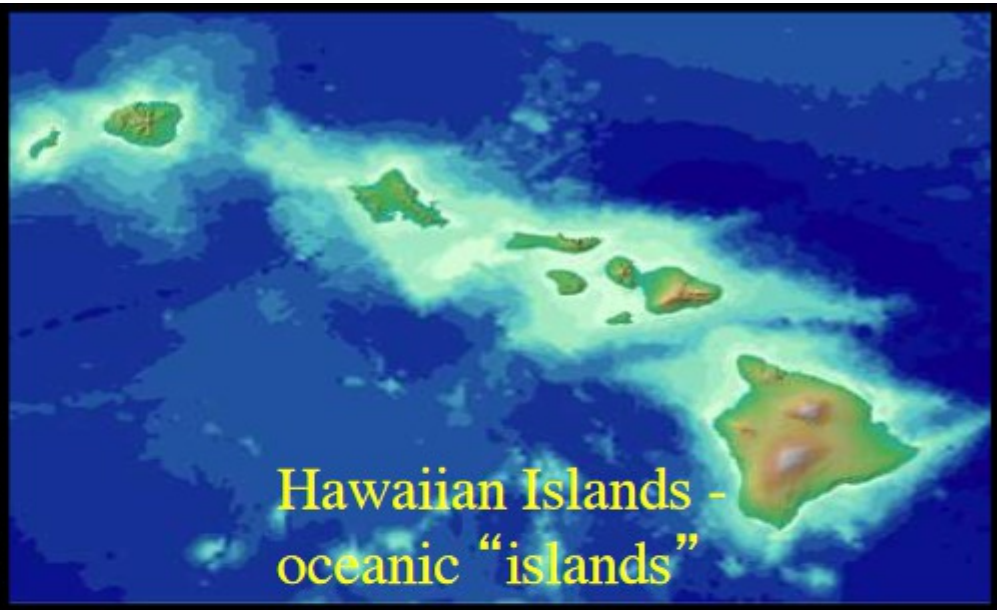
"Island" Model of Speciation

• A rapid form of peripheral isolation and speciation involving "island" like habitats completely separated from contact

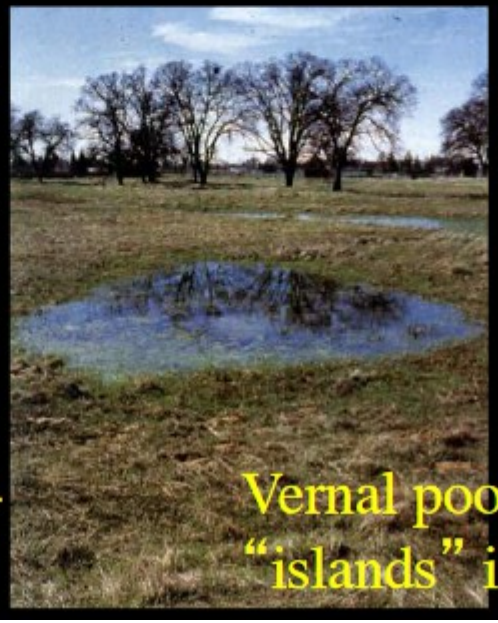
• The founder event often involves a very small subset of the original genetic pool of the ancestral species — thus differences accumulate rapidly

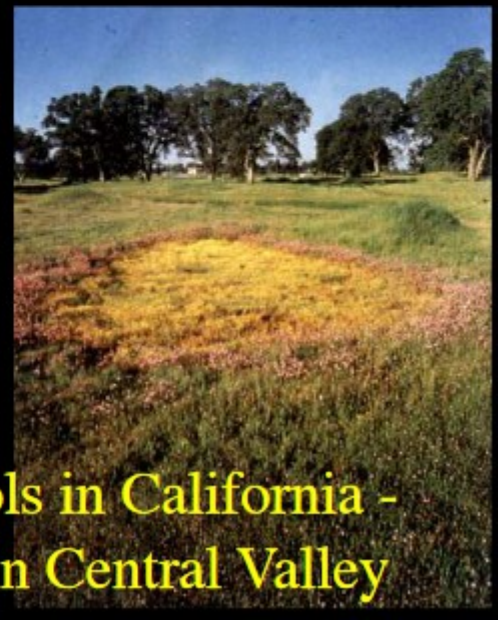


Tepuis in Venezuela -
continental "islands"



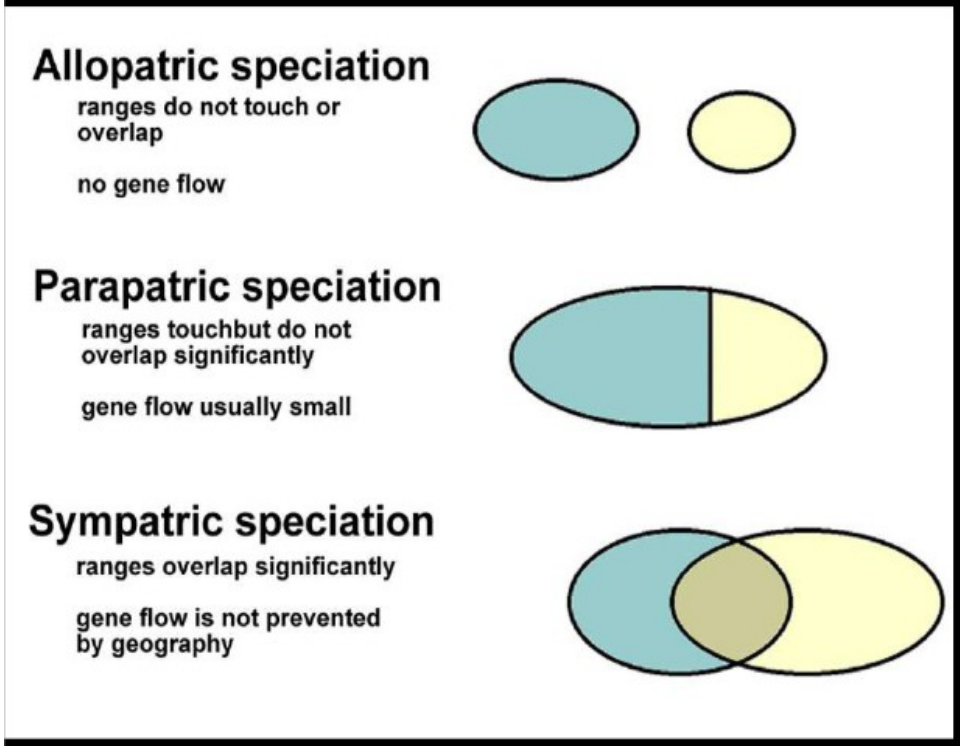
Hawaiian Islands -
oceanic "islands"





Vernal pools in California -
"islands" in Central Valley

Sympatric Speciation

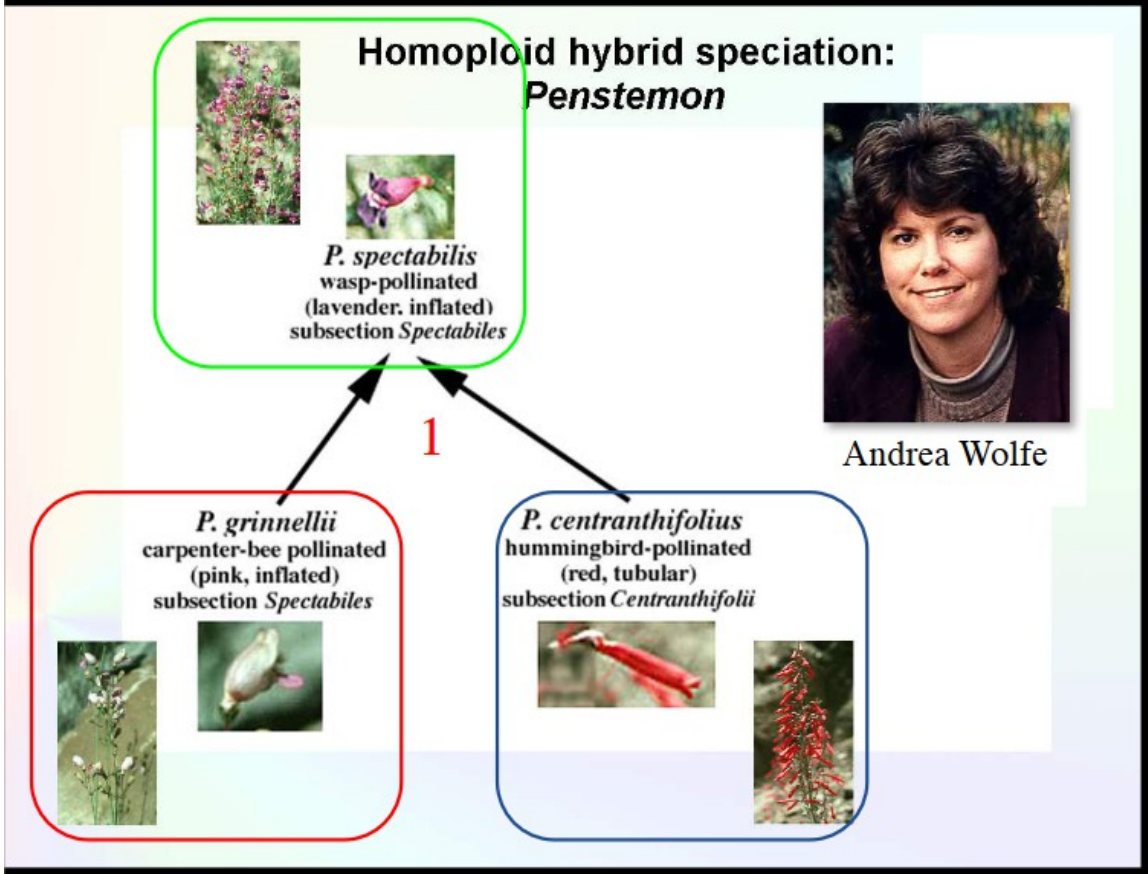


Two types of sympatric speciation where gene flow is not prevented by geography are:

(1) diploid or homoploid hybrid speciation

(2) allopolyloid speciation

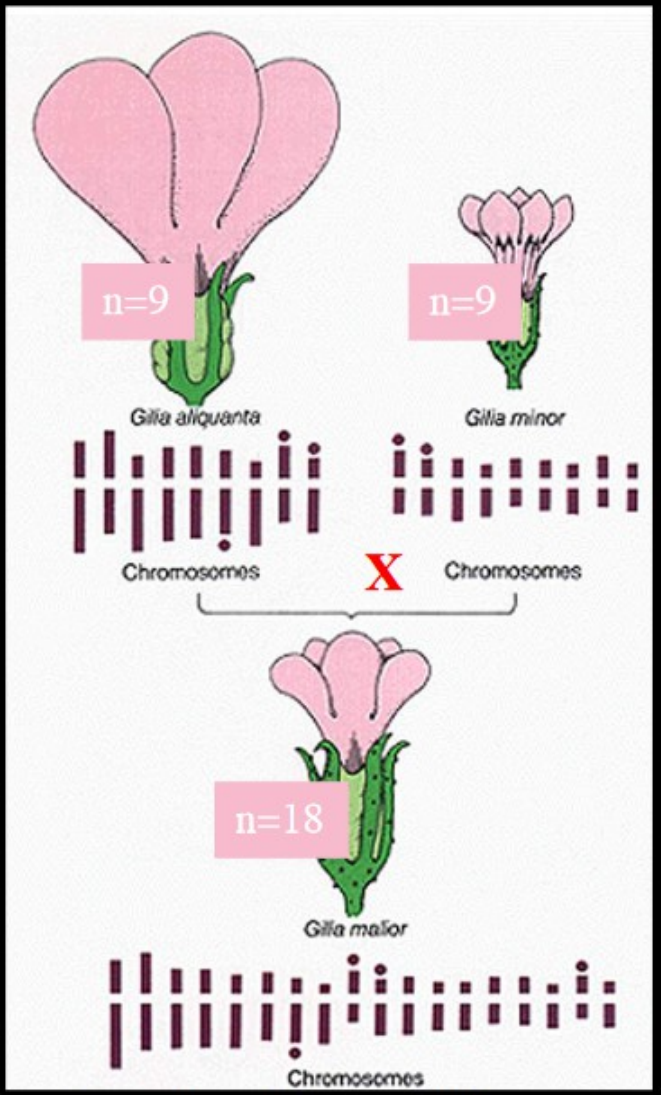
Homoploid Hybrid Speciation



Andrea Wolfe

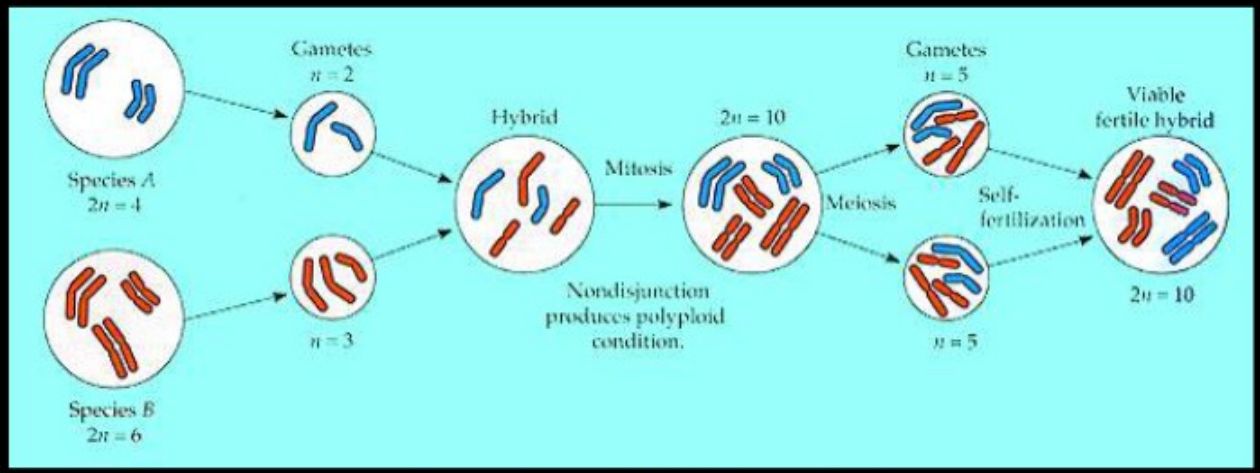
- two parental species differ in habitat, floral form, pollinators
- *P. spectabilis* is intermediate in habitat, floral form, and isolated by new pollinator

Polyploid Speciation



A very common and instantaneous form of speciation in plants (and a few animals) is allopolyploidy.

- hybridization occurs between two species
- meiotic incompatibilities makes hybrid sterile
- doubling of chromosomes occurs (polyploidy)
- allopolyploid is fertile and reproductively isolated from both parental species



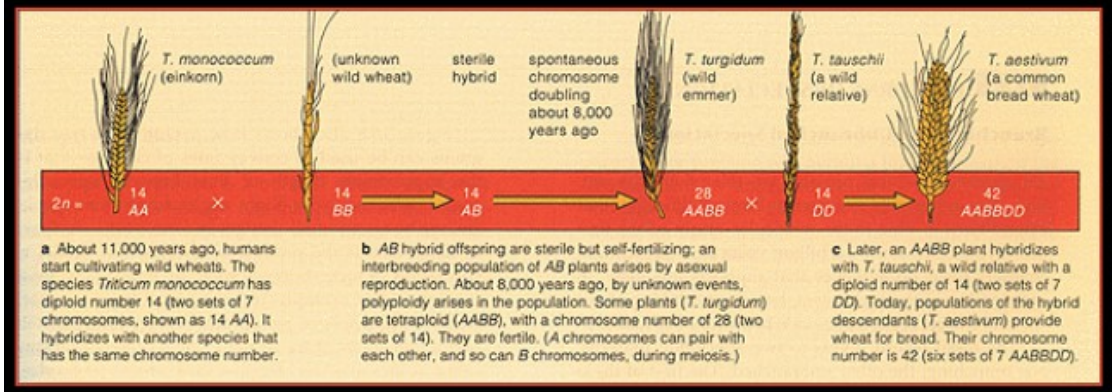
2 species with same "n"

2 species with different "n"

Polyploid Speciation

Under human selection in the Middle East, bread wheat (*Triticum aestivum*) has evolved in about 11,000 years.

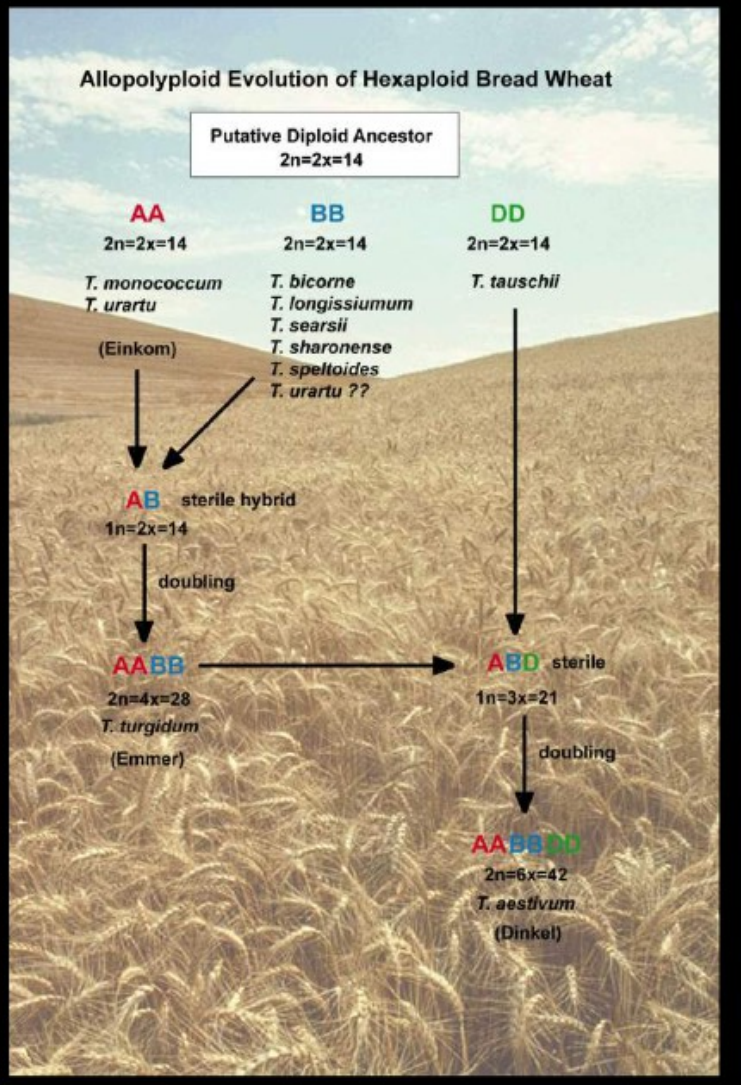
Two successive rounds of hybridization followed by polyploidization have given bread wheat the genomes of three diploid species — it is a hexaploid (6 sets of chromosomes, or 2 from each diploid parental species).

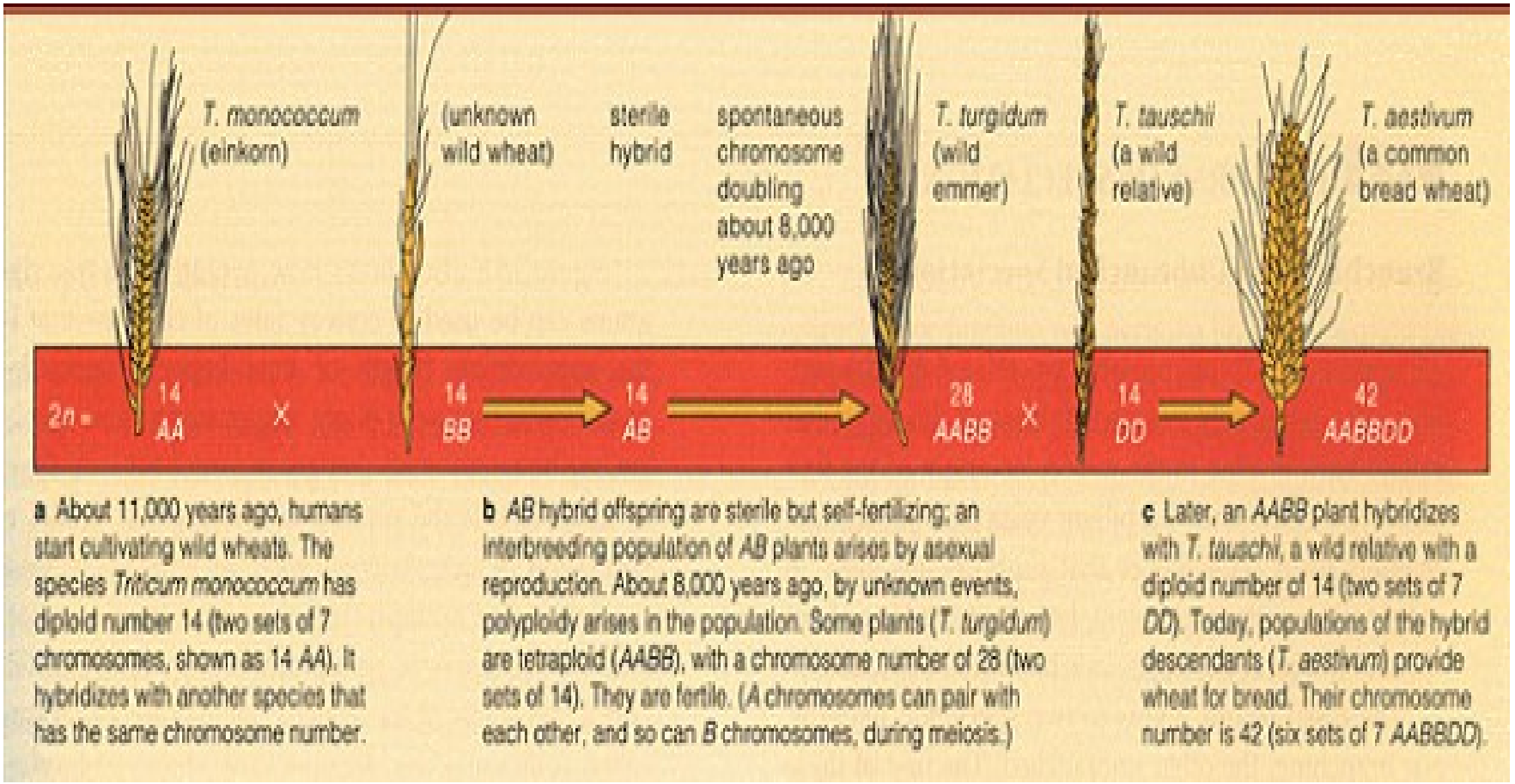


a About 11,000 years ago, humans start cultivating wild wheats. The species *Triticum monococcum* has diploid number 14 (two sets of 7 chromosomes, shown as 14 *A*). It hybridizes with another species that has the same chromosome number.

b *AB* hybrid offspring are sterile but self-fertilizing; an interbreeding population of *AB* plants arises by asexual reproduction. About 8,000 years ago, by unknown events, polyploidy arises in the population. Some plants (*T. turgidum*) are tetraploid (*AABB*), with a chromosome number of 28 (two sets of 14). They are fertile. (*A* chromosomes can pair with each other, and so can *B* chromosomes, during meiosis.)

c Later, an *AABB* plant hybridizes with *T. tauschii*, a wild relative with a diploid number of 14 (two sets of 7 *DD*). Today, populations of the hybrid descendants (*T. aestivum*) provide wheat for bread. Their chromosome number is 42 (six sets of 7 *AABBDD*).





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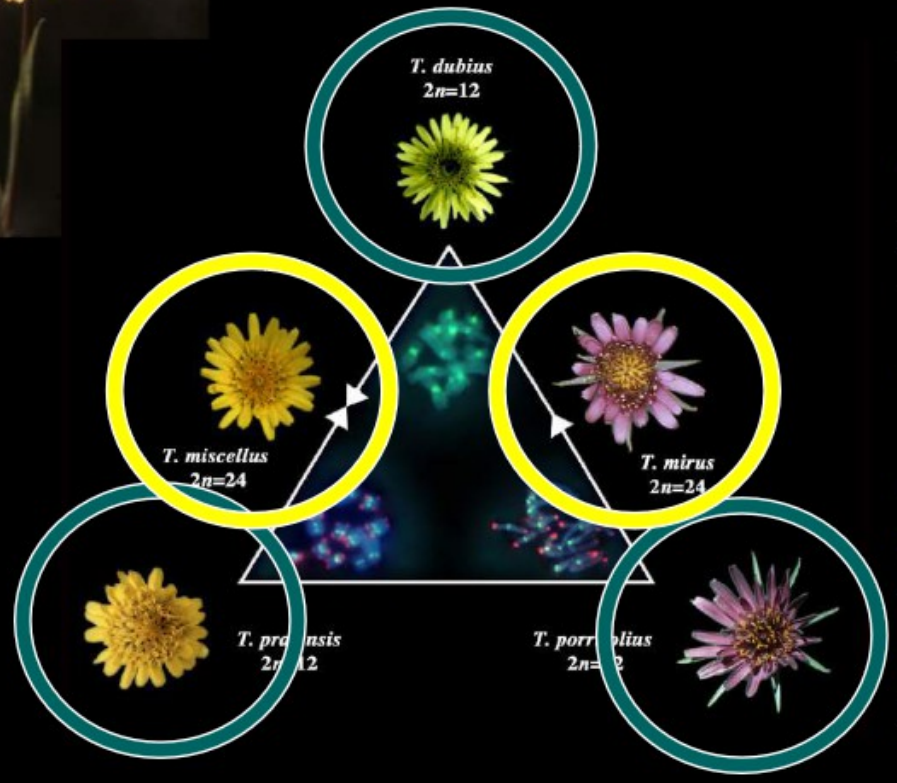
Evoluzione per poliploidia del grano (*Triticum*)

Polyploid Speciation

Even more recent speciation has occurred in the goat's-beards in North America.

Tragopogon - goat's beard



- Three diploid (2n=12) species were introduced into North America about 200 years ago
- By early 1900s, these species had hybridized with each other and then formed two different allopolyploid (tetraploid) species
- These two new allopolyploid species have evolved numerous times (!) in areas where the diploid species overlap in geographical range in North America

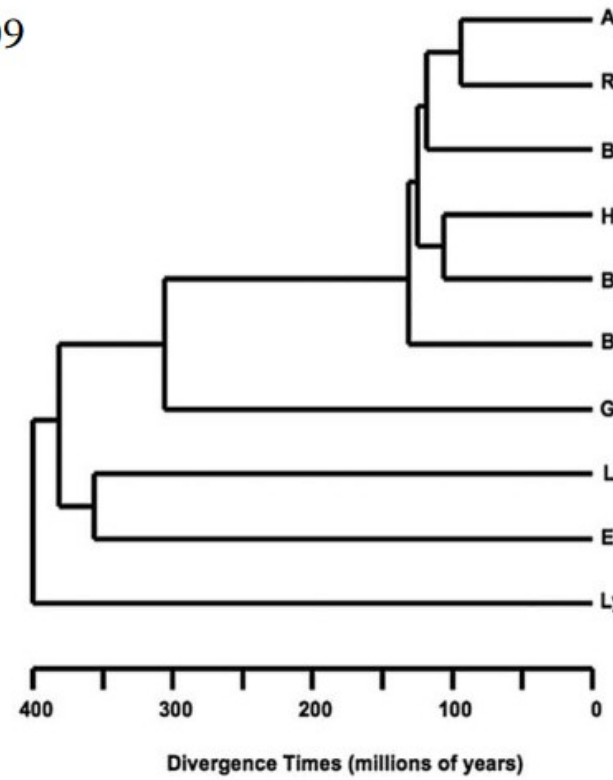
Polyploid Speciation

Loren Rieseberg

The frequency of polyploid speciation in vascular plants

Troy E. Wood[a,b,1], Naoki Takebayashi[c], Michael S. Barker[b,d], Itay Mayrose[e], Philip B. Greenspoon[d], and Loren H. Rieseberg[b,d]

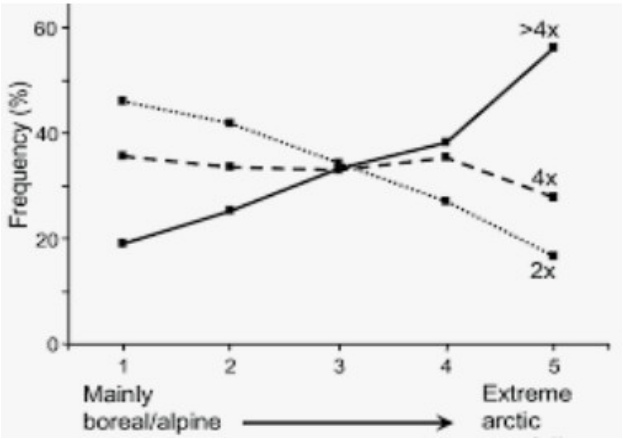
2009

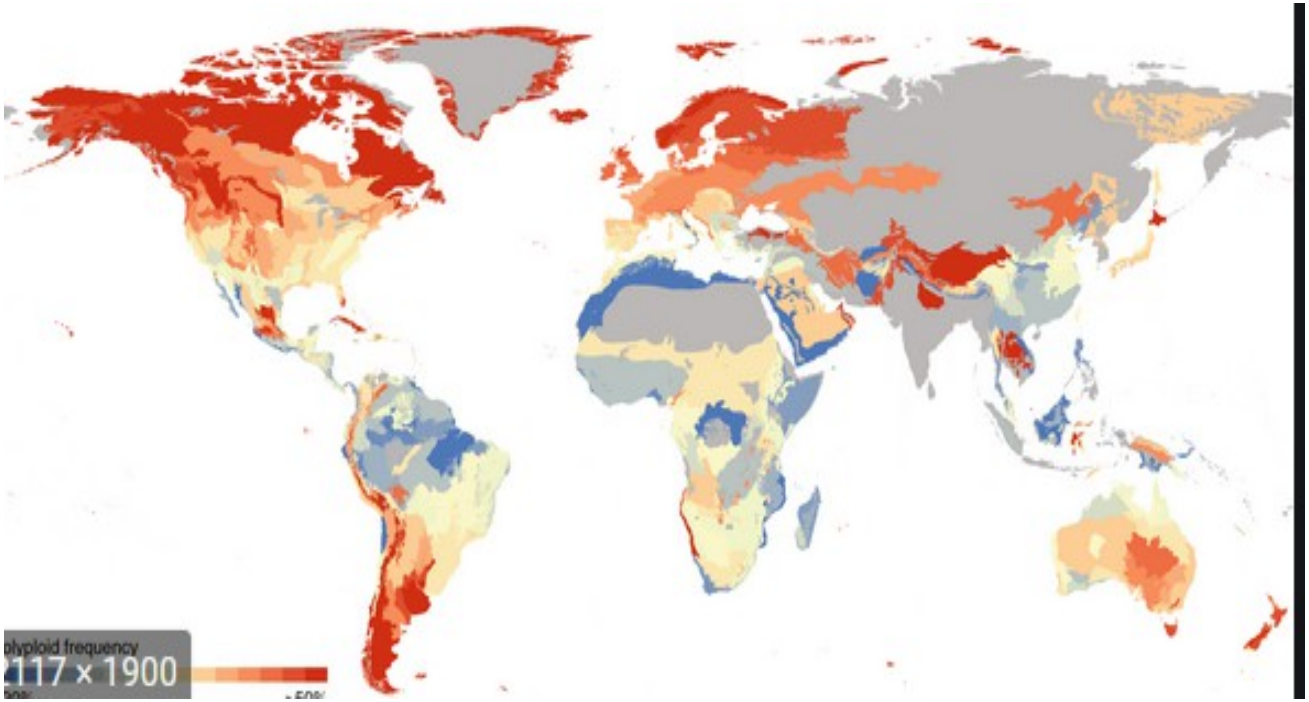


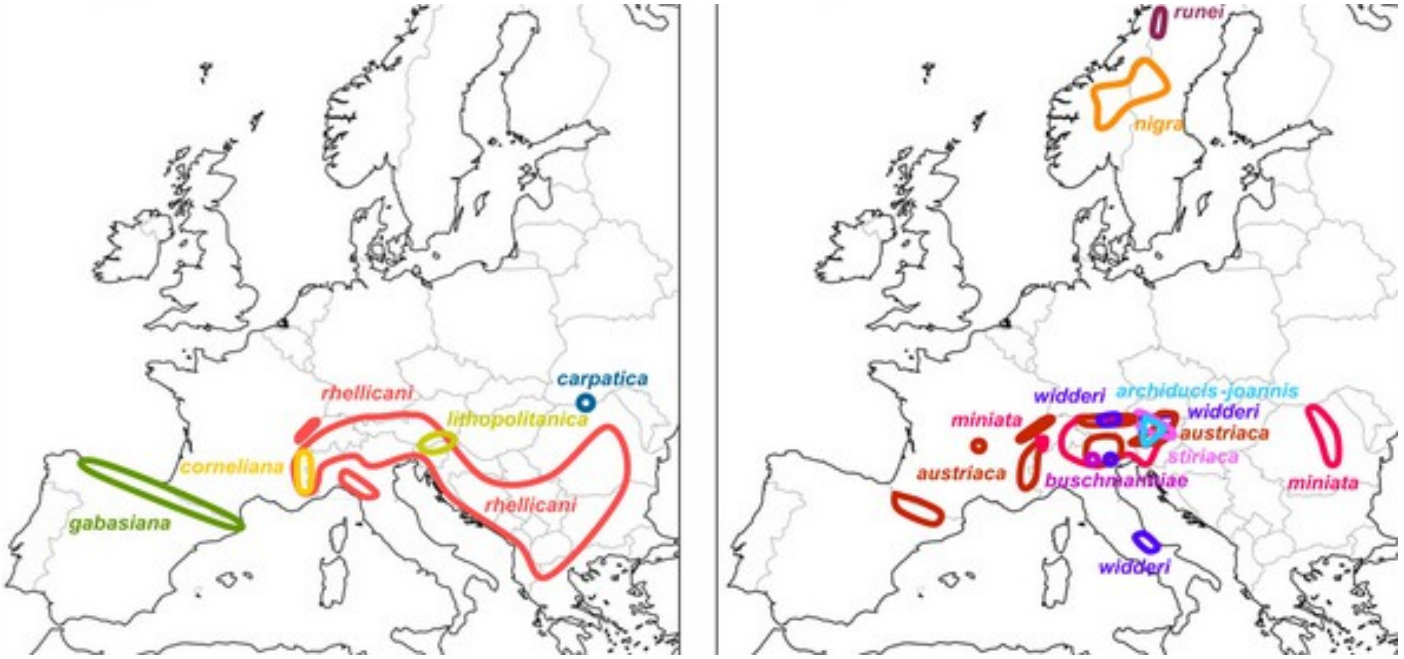
	No. Species	Infrageneric Polyploid Incidence	Polyploid Speciation Frequency
Asterids	106,150	35.05 ± 1%	12.45 ± 1%
Rosids	58,700	31.91 ± 2%	20.63 ± 2%
Basal Eudicots	24,950	37.24 ± 2%	14.11 ± 2%
Higher Monocots	28,150	46.58 ± 2%	21.43 ± 5%
Basal Monocots	33,180	29.94 ± 2%	25.74 ± 4%
Basal Angiosperms	9,250	37.57 ± 6%	1.64 ± 2%
Gymnosperms	830	4.04 ± 3%	– – –
Leptospor. Ferns	11,000	32.86 ± 2%	34.01 ± 4%
Eusporangiate Ferns	380	24.00 ± 7%	19.36 ± 7%
Lycophytes	1,200	33.61 ± 10%	30.77 ± 9%

15.00%

31.37%


60
40
20
0
Frequency (%)
>4x
4x
2x
1
2
3
4
5
Mainly
boreal/alpine
Extreme
arctic


117 x 1900



Evoluzione di specie poliploidi in *Nigritella*

ORCHIDACEAE

ORCHIDACEAE

ORCHIDACEAE

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ORCHIDACEAE

1. Hierarchical Classification

Characters are "fossil" footprints indicating ancestry

- but rather each inherited it from a *common ancestor* who first derived it — *a "fossil" footprint*

- a consensus tree depicts the maximum information possible from all most parsimonious trees (note: not equal to phenogram)