

# ~Oaks of Washington DC and beyond~

## ~what's queer about *Quercus*~



# Credits and Acknowledgements

The impetus for this project was the “2012 MNPS Year of the Oak”



Most images are my own;  
these here and a few  
others are common  
domain on the internet



# Quirk 1 - *Quercus*

- quer [German] in the sense of twisted or contorted
- queer [English]
- oak =? a sound shift  
=(q)uirk =irk =oak



- So how is *Quercus* queer?  
Abnormally formed

**Once upon a time  
the English oak was  
a forest tree**



*Most species are described as round-topped trees*



# Quirk 2 - bark

Which species are these?



# Quirk 2 - bark

*Quercus alba* (sock)



*Quercus alba* (trunk)



*Q. alba*



*Q. montana*



**ridges and furrows**  
**tiles or tessellations**  
**scales or plates**

*Q. rubra*



*Q. phellos*



*Q. falcata*



*Q. marilandica*





# Quirk 3 - leaves

## Three types of leaf

- Bud scales
- Inflorescence scales and bracts (sometimes confused with stipules)
- Planar leaves

**There are also true stipules!!**



# Bud scales

**Terminal cluster of buds**

**Bud shape**

- **length:width ratio**
- **hairs**

***Q. alba***



***Q. lyrata***



***Q. macrocarpa***



***Q. michauxii* *Q. montana***



***Q. falcata***



***Q. marilandica***



***Q. palustis***



***Q. phellos***



***Q. rubra***



Images from the web

*Q. marilandica*



# So what shape is it?

**Blade (lamina)**

- widest point
- length:width ratio
- angle at base
- domatia (hair tufts)
- vein for every lobe
- # of bristles (awns)

**Length of petiole**



*Q. alba*



*Q. falcata*

*Q. shumardii*





Quercus  
alba  
Little Rock,  
Arkansas

***Q. alba***



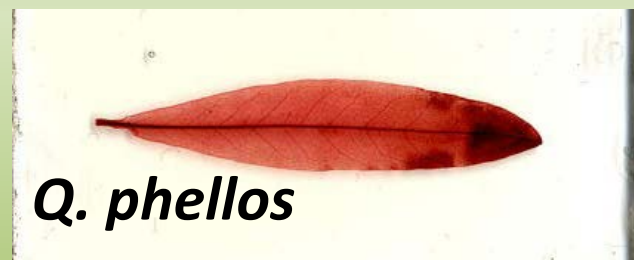
Quercus  
prinus  
Rock Creek  
Wash. D.C.

***Q. montana***



Quercus  
coccinea  
Rock Creek  
Wash. D.C.

***Q. coccinea***



***Q. phellos***



***Q. acutissima***

Stipules on *Quercus phellos*





# Quirk 4 - senescence of leaves

- Evergreen (live oaks)
- Deciduous (?dead oaks)

**Why do some oaks hold their leaves virtually through to spring?**

- abscission layer causes leaf fall

**There are both red and white “live” oaks**

# Quirk 5 - flowers

- catkins (Dutch), aments (Latin), spikes (English)
- Male inflorescences has many 60-120 flowers with virtually no pedicel (flower stalk)
- Female inflorescences have few flowers with virtually no pedicel

But how do we make an acorn?



# Males

Clusters of +/- 3

- sessile on spikes
- stamens # 4-8





*Quercus alba*



*Quercus montana*

*Quercus phellos*



*Quercus falcata*



*Quercus palustris*



*Quercus rubra*





# Females

Clusters of +/- 3

- styles short vs long
- sessile or on spikes





*Q. alba*



*Q. montana*



*Q. falcata*



*Q. rubra*



# white oak

# red oak

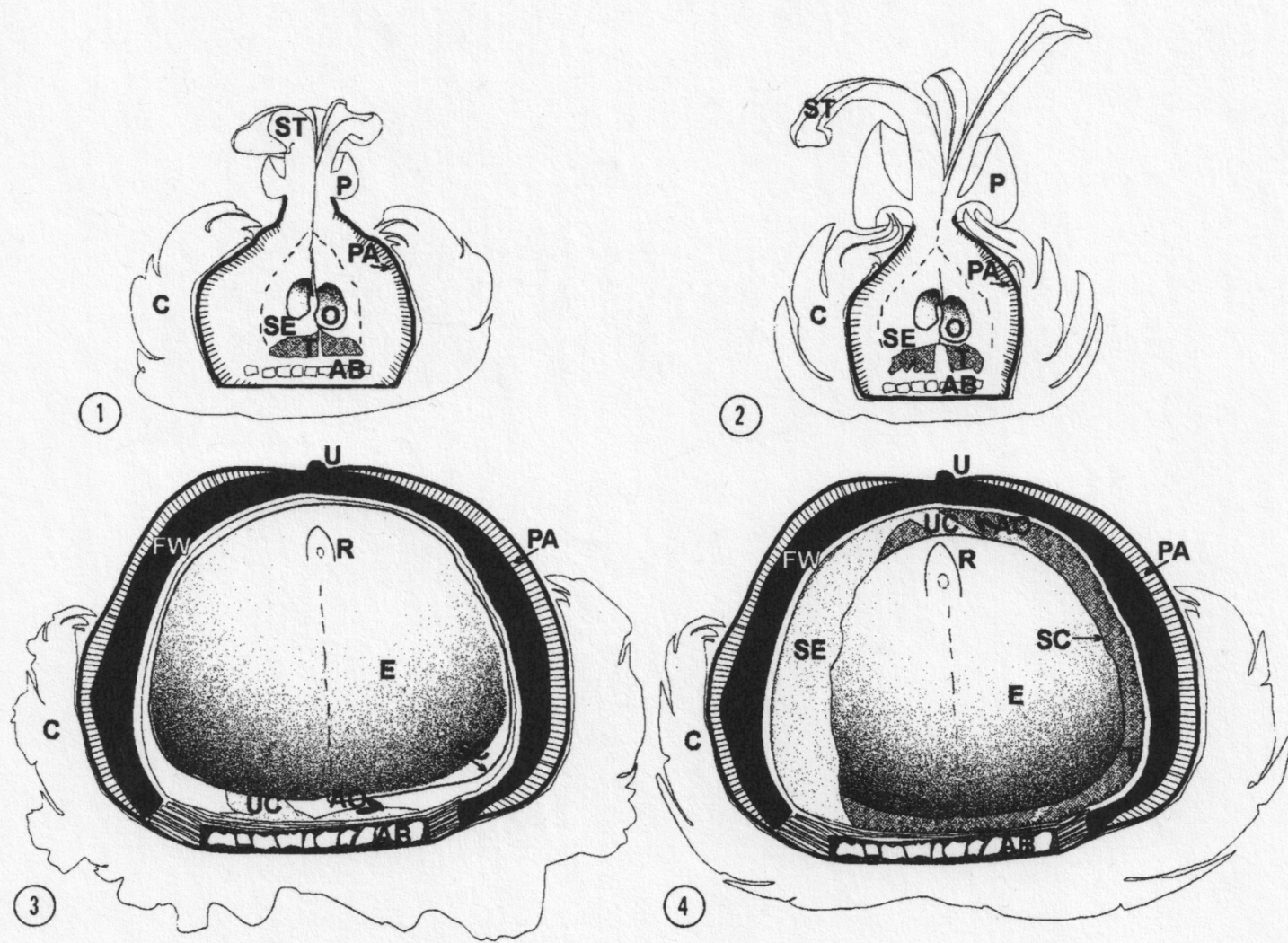
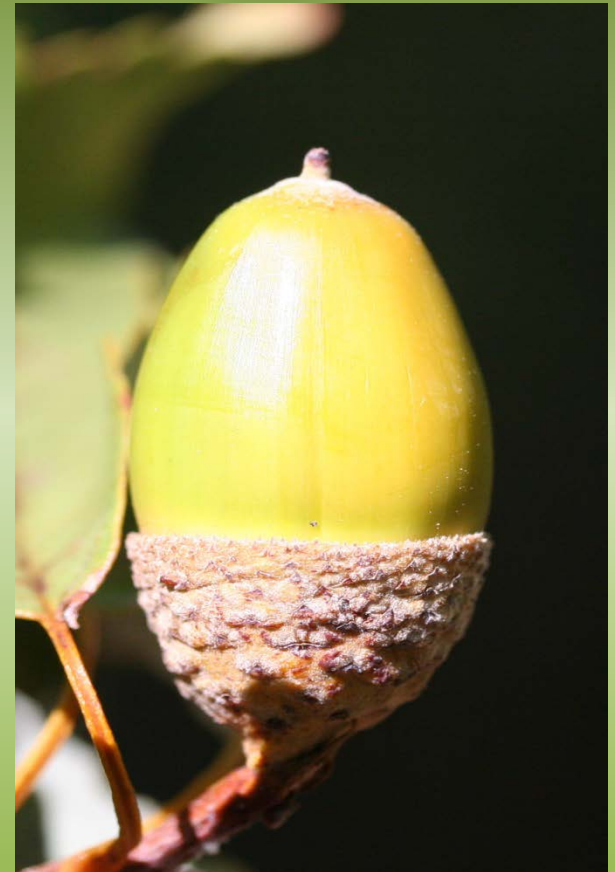


Figure Abbreviations: AB, abscission zone; AO, abortive ovule(s); C, cupule; CS, cupule scale(s); E, embryo; EN, endosperm; FW, fruit wall; L, locule(s); O, ovule(s); P, perianth; PA, palisade layer; PD, peduncle; PL, perianth lobe(s); R, radicle; S, seed; SC, seed coat; SE, septum(-a); ST, style(s); T, trichomes; U, umbo; UC, umbilical complex.

# Quirk 6 - fruit

- Acorns consist of the nut and the cup (cupule)
- Size does not matter





*Q. marilandica*  
2 years of fruit





# *Quercus* background

- How old are the oaks? Pollen from middle Oligocene (28-30 mybp)
- How many are there today? 400+150=550 spp.
  - white = 200 *Quercus* sect. *Quercus*
  - intermediate = 5 *Quercus* sect. *Protobalanus*
  - red = 195 *Quercus* sect. *Lobatae*
  - ring cups = 150 Asian ?genus: *Cyclobalanus*

# Is it white or is it red?

| Character        | white oak (c.200 spp.)   | red oak (c.195 spp.)               |
|------------------|--------------------------|------------------------------------|
| Style            | Short (~0.5-1mm)         | Long (~1.5-2mm)                    |
| Acorn maturation | 6 months                 | 18 months                          |
| Acorn taste      | Sweet to slightly bitter | Very bitter                        |
| Acorn cup        | No hairs                 | Hairy<br>(few Asian w/o)           |
| Leaf lobes       | Without awns             | With awns                          |
| Leaf lobes       | Rounded tips             | Sharp pointed tips<br>(rarely not) |

# DC-Maryland - 21 species + 2 exotic

- **9 white oaks + 1**

- white cut : *Q. alba*, *Q. bicolor*, *Q. lyrata*, *Q. macrocarpa*, *Q. stellata* + *Q. robur*
- chestnut : *Q. bicolor*, *Q. michauxii*, *Q. muehlenbergii*, *Q. prinoides*, *Q. montana* (*Q. prinus*)

- **12 red oaks + 1**

- red cut : *Q. coccinea*, *Q. falcata*, *Q. ilicifolia*, *Q. pagoda*, *Q. palustris*, *Q. rubra*, *Q. shumardii*
- red +/- not cut : *Q. imbricaria*, *Q. phellos*, *Q. marilandica*, *Q. nigra* + ~ *Q. acutissima*
- black cut : *Q. velutina*



# How to identify DC-Maryland's oaks

| Bark                        | Ridges, scales or tiles (tessellations)    |
|-----------------------------|--|
| Petiole (leaf stalk) length |  |
| Lamina (blade) shape        | Ovate, elliptical, obovate, etc.           |
| Lamina lobes and veins      | Lobe for every vein or not, lobes how deep |
| Lamina indumentum (hairs)   | Present or absent                          |
| Bristles (awns)             | Present or absent                          |
| Domatia (hairy vein axils)  | Present or absent                          |

***Q. alba, Q. lyrata, Q. macrocarpa, Q. stellata*  
+ *Q. robur* (white oaks)**

***Blades deeply lobed; each secondary vein not ending in a lobe***

**Blades glabrous below**

- ***Q. lyrata* – wide lobes; spreading sinuses; apices acute to obtuse**
- ***Q. alba* – finger-like lobes; narrow sinuses; apices rounded; bases attenuate**
- ***Q. robur* - finger-like lobes; narrow sinuses; apices rounded; bases cordate**

**Blades hairy below**

- ***Q. stellata* – most petioles <15 mm long**
- ***Q. macrocarpa* - most petioles >15 mm long**



***Q. bicolor, michauxii, Q. montana, Q. muehlenbergii, Q. prinoides* (white oaks)**

***Blades shallow lobes; each secondary vein ending in a lobe***

**Lobes obtuse to rounded**

- ***Q. montana* – 9 or more lobes per side; obovate; pubescent below**
- ***Q. bicolor* – <9 lobes; obovate; papery; pubescent below**
- ***Q. prinoides* – <9 lobes; narrowly obovate; leathery; glabrescent below**



**Lobes acute**

- ***Q. michauxii* – base obtuse to truncate; yellow-green hairs below or glabrous**
- ***Q. muehlenbergii* - base rounded; white hairs below**

# *Q. imbricaria*, *Q. phellos* + ~*Q. acutissima* (red oaks)

*Petioles usually less than 20(-25) mm long*

**Blades lacking lobes**

- *Q. phellos* – elliptical to linear; terminal bristle
- *Q. imbricaria* – obovate to oblanceolate; terminal bristle

**Blades shallowly lobed throughout**

- *Q. acutissima* – lanceolate; many lateral bristles



***Q. ilicifolia, Q. marilandica, Q. nigra***  
**(red oaks)**

***Petioles usually less than 20(-25) mm long***

**Blades shallowly lobed distally**

- ***Q. marilandica* – obovate, +/- as long as wide**
- ***Q. nigra* – obovate to oblanceolate, 2X as long as wide**

**Blades deeply lobed proximally**

- ***Q. ilicifolia* – ovate to obovate, +/- as long as wide**

***Q. falcata, Q. pagoda, Q. velutina***  
**(red & black oaks)**

***Petioles usually more than (20-)25 mm long***

**Blades hairy below; 1-2(-3) bristles per lobe**

- ***Q. falcata* – 1-2(-3) lobes per side; terminal lobe longer than laterals; gray pubescent**
- ***Q. pagoda* – (2-)3-5 lobes per side; terminal lobe shorter than laterals; rusty pubescent**

**Blades glabrescent below; 3-10 bristles per lobe**

- ***Q. velutina* – 2-3(4) lobes per side; terminal lobe shorter than laterals; gray pubescent**

***Q. coccinea, Q. palustris, Q. rubra, Q. shumardii,*  
*Q. velutina* (red & black oaks)**

**Blades glabrous below; 3-10 bristles per lobe**

**Deep sinuses  $>2/3$  to midvein**

- ***Q. palustris* – middle lobe right angle to midvein**
- ***Q. coccinea* – lobes acute, distally wide; blade:petiole  $<3$**
- ***Q. shumardii* – lobes acute, distally wide; blade:petiole  $>3$**
- ***Q. velutina* – lobes acute, +/- not expanded; blade:petiole  $>3$**

**Shallow sinuses  $<2/3$  to midvein**

- ***Q. rubra* - lobes acute, +/- not expanded; blade:petiole  $>3$**



# Quirk 7 - promiscuity

- rampant hybridization and gene introgression

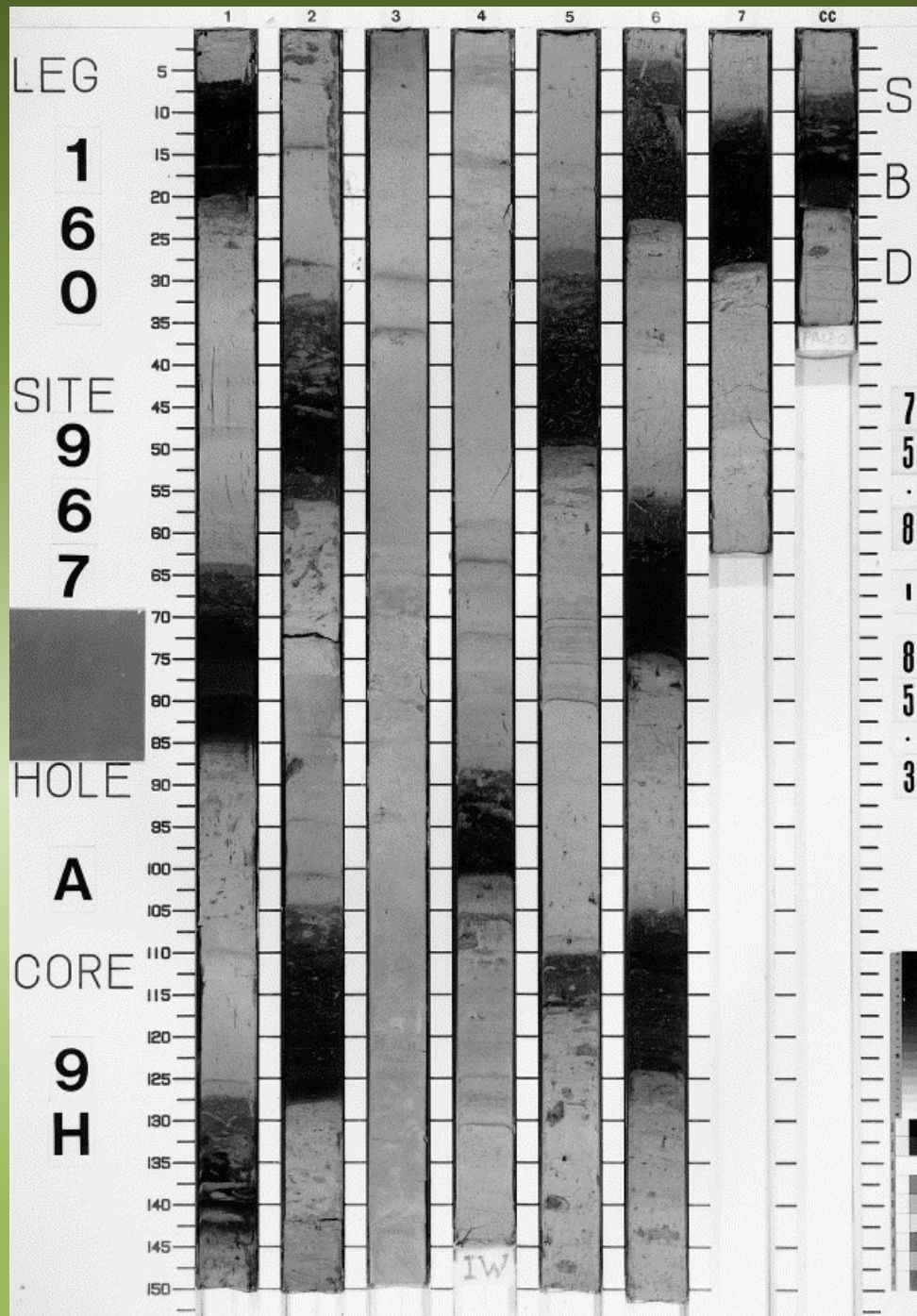
**Speciation - how does it occur?**

- Wind pollinated (no insect vectors), narrow window for fertilization
- Genetic barriers to fertilization - sterility
- Climate change and erratic climate events



**How many  
ice ages  
have there  
been in the  
last million  
years?**





# Climate Change

Marine sediment core showing 13 sapropel cycles - carbon dated to 23,000 year ice age cycle

About 40 ice ages in the last million years

# Named and unnamed white oak hybrids

|   | white oaks                                | <i>Q. alba</i>                           | <i>Q. bicolor</i>                    | <i>Q. lyrata</i>   | <i>Q. macrocarpa</i>  | <i>Q. michauxii</i> | <i>Q. montana</i><br>( <i>Q. prinus</i> ) | <i>Q. muelhenbergii</i> | <i>Q. prinoides</i> | <i>Q. stellata</i> |
|---|---|--|--------------------------------------|--------------------|-----------------------|---------------------|---|-------------------------|---------------------|--------------------|
| 1 | <i>Q. alba</i>                            | <i>self</i>                              |                                      |                    |                       |                     |   |                         |                     |                    |
| 2 | <i>Q. bicolor</i>                         | <i>×jackiana</i>                         | <i>self</i>                          |                    |                       |                     |   |                         |                     |                    |
| 3 | <i>Q. lyrata</i>                          | <i>x</i>                                 | <i>×humidicola</i>                   | <i>self</i>        |                       |                     |   |                         |                     |                    |
| 4 | <i>Q. macrocarpa</i>                      | <i>×bebbiana,</i><br><i>(×schuettei)</i> | <i>×hillii,</i><br><i>×schuettei</i> | <i>×megaleia</i>   | <i>self</i>           |                     |   |                         |                     |                    |
| 5 | <i>Q. michauxii</i>                       | <i>×beadleii</i>                         | <i>o</i>                             | <i>×tottenii</i>   | <i>×byarsii</i>       | <i>self</i>         |   |                         |                     |                    |
| 6 | <i>Q. montana</i><br>( <i>Q. prinus</i> ) | <i>×saulii</i>                           | <i>x</i>                             | <i>o</i>           | <i>o</i>              | <i>o</i>            | <i>self</i>                               |                         |                     |                    |
| 7 | <i>Q. muelhenbergii</i>                   | <i>(×deamii)</i>                         | <i>o</i>                             | <i>o</i>           | <i>×deamii</i>        | <i>o</i>            | <i>o</i>                                  | <i>self</i>             |                     |                    |
| 8 | <i>Q. prinoides</i>                       | <i>×faxonii</i>                          | <i>×wagneri</i>                      | <i>o</i>           | <i>×beckyaee</i>      | <i>x</i>            | <i>o</i>                                  | <i>×introgressa</i>     | <i>self</i>         |                    |
| 9 | <i>Q. stellata</i>                        | <i>×fernowii</i>                         | <i>×substellata</i>                  | <i>×sterrettii</i> | <i>×guadalupensis</i> | <i>o</i>            | <i>×bernardensis</i>                      | <i>o</i>                | <i>×stelloides</i>  | <i>self</i>        |

# Named and unnamed red oak hybrids

|    | red oaks              | <i>Q. coccinea</i> | <i>Q. falcata</i>                           | <i>Q. ilicifolia</i> | <i>Q. imbricaria</i>                        | <i>Q. marilandica</i> | <i>Q. nigra</i>     | <i>Q. pagoda</i>     | <i>Q. palustris</i> | <i>Q. phellos</i>  | <i>Q. rubra</i>    | <i>Q. shumardii</i> | <i>Q. velutina</i> |
|----|-----------------------|--------------------|---|----------------------|---|-----------------------|---------------------|----------------------|---------------------|--|--------------------|---------------------|--------------------|
| 1  | <i>Q. coccinea</i>    | self               |   |                      |   |                       |                     |                      |                     |  |                    |                     |                    |
| 2  | <i>Q. falcata</i>     | o                  | self  |                      |   |                       |                     |                      |                     |  |                    |                     |                    |
| 3  | <i>Q. ilicifolia</i>  | × <i>robbinsii</i> | × <i>caesariensis</i>                       | self                 |   |                       |                     |                      |                     |  |                    |                     |                    |
| 4  | <i>Q. imbricaria</i>  | x                  | × <i>anceps</i><br>× <i>palmeriana</i>      | o                    | self  |                       |                     |                      |                     |  |                    |                     |                    |
| 5  | <i>Q. marilandica</i> | o                  | × <i>incomita</i>                           | × <i>brittonii</i>   | × <i>tridentata</i>                         | self                  |                     |                      |                     |  |                    |                     |                    |
| 6  | <i>Q. nigra</i>       | o                  | × <i>garlandensis</i>                       | o                    | o   | × <i>sterilis</i>     | self                |                      |                     |  |                    |                     |                    |
| 7  | <i>Q. pagoda</i>      |                    | x   |                      |   |                       |                     | self                 |                     |  |                    |                     |                    |
| 8  | <i>Q. palustris</i>   | x                  | o   | o                    | × <i>exacta</i>                             | x                     | x                   |                      | self                |  |                    |                     |                    |
| 9  | <i>Q. phellos</i>     | x                  | × <i>subfalcata</i>                         | × <i>giffordii</i>   | x   | × <i>rudkinii</i>     | × <i>capessii</i>   | × <i>ludoviciana</i> | × <i>schochiana</i> | self   |                    |                     |                    |
| 10 | <i>Q. rubra</i>       | × <i>benderi</i>   | o   | × <i>fernaldii</i>   | × <i>runcinata</i>                          | x                     | x                   |                      | × <i>columnaris</i> | × <i>heterophylla</i>  | self               |                     |                    |
| 11 | <i>Q. shumardii</i>   | o                  | × <i>joori</i>                              | o                    | × <i>egglestonii</i><br>× <i>shirlingii</i> | × <i>hastingsii</i>   | × <i>neopalmeri</i> |                      | × <i>mutabilis</i>  | × <i>moultonensis</i>  | × <i>riparia</i>   | self                |                    |
| 12 | <i>Q. velutina</i>    | × <i>fontana</i>   | × <i>wildenowiana</i><br>× <i>pinetorum</i> | × <i>rehderi</i>     | × <i>leana</i>                              | × <i>bushii</i>       | × <i>demarei</i>    |                      | × <i>vaga</i>       | × <i>filialis</i> , × <i>dubia</i> ,<br>× <i>xinaequalis</i> | × <i>hawkinsii</i> | × <i>discreta</i>   | self               |

# Hybrids in oaks – where are they?

- **Wherever there is sympatry (species of the same group coexisting are likely to form F1s, rarely hybrid swarms)**

- **What do hybrids look like?**

**Something resembling both or shared character states of both parents, generally suggested by the leaf morphology and/or by the fruit**

# Quirk 8 – Molecular story

- North American species: 35r, 4i, 51w = 90
- AFLPs and microsatellites – work on Californian and neighboring Mexico, mostly on hybrid complexes, little in the east
- A survey of Genbank retrieved a dozen gene region sequenced for very few mid-Atlantic species
- DNAs of four/six N. Am. spp. ITS/CRC genes in world-wide studies of the generic/sectional phylogenetics (Oh & Manos 2008)

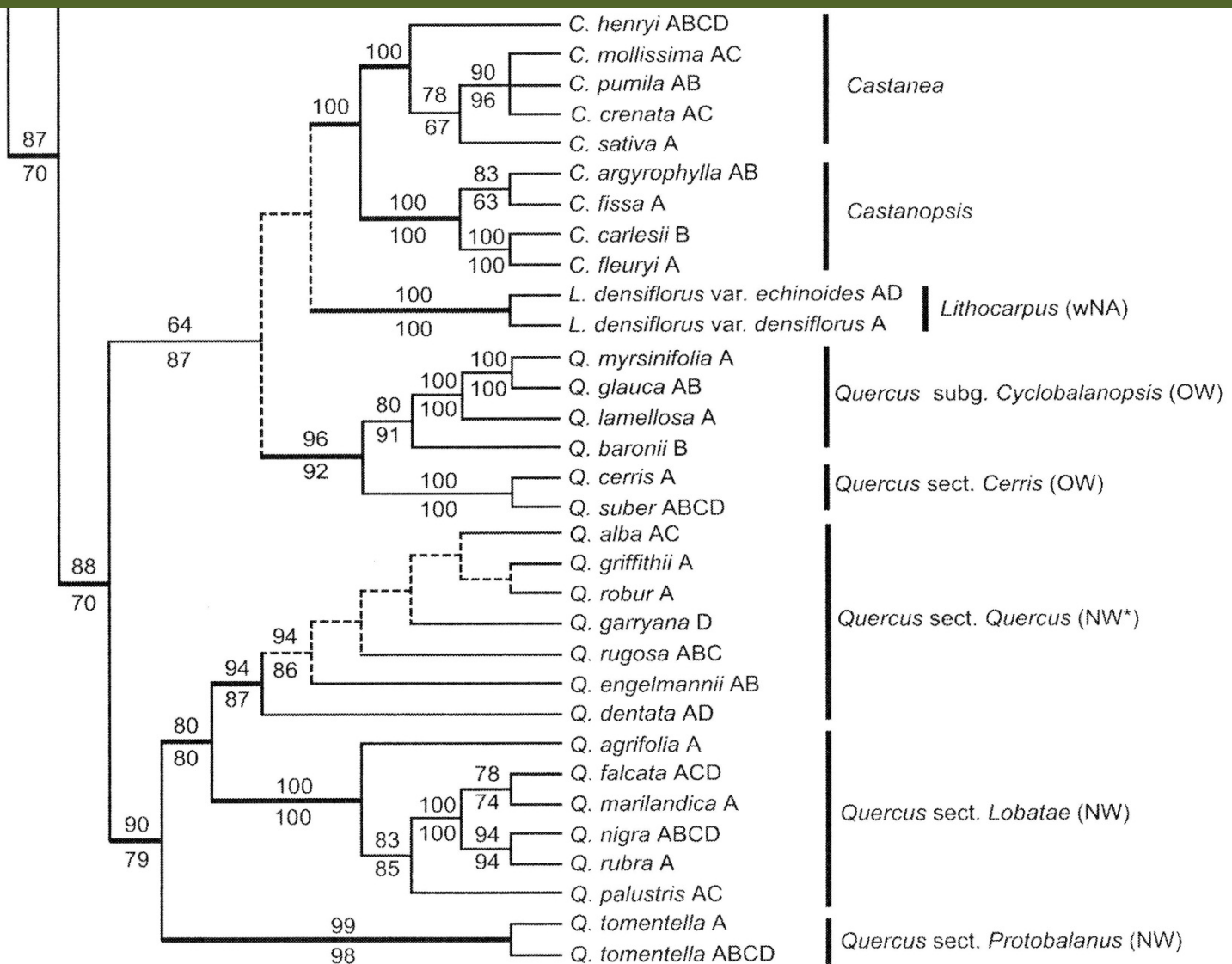


Fig. 4. Maximum likelihood tree from the analysis of the CRC data. Dashed lines indicate the branches that collapse in the strict consensus tree based on MP analysis. Bootstrap proportions using MP are indicated above branches and those based on ML are below. Strongly supported major clades are indicated with thick branches. Capital letters following taxon names refer to clone identifiers. Only one randomly selected sequence per accession was included in the analyses. A representative MP tree with all cloned sequences is provided in Appendix 2 (in Taxon online issue). NW = New World; OW = Old World; and wNA = western North America. The asterisk notes that most species of *Quercus* sect. *Quercus* are distributed in the New World, except for approximately 20 Eurasian species.

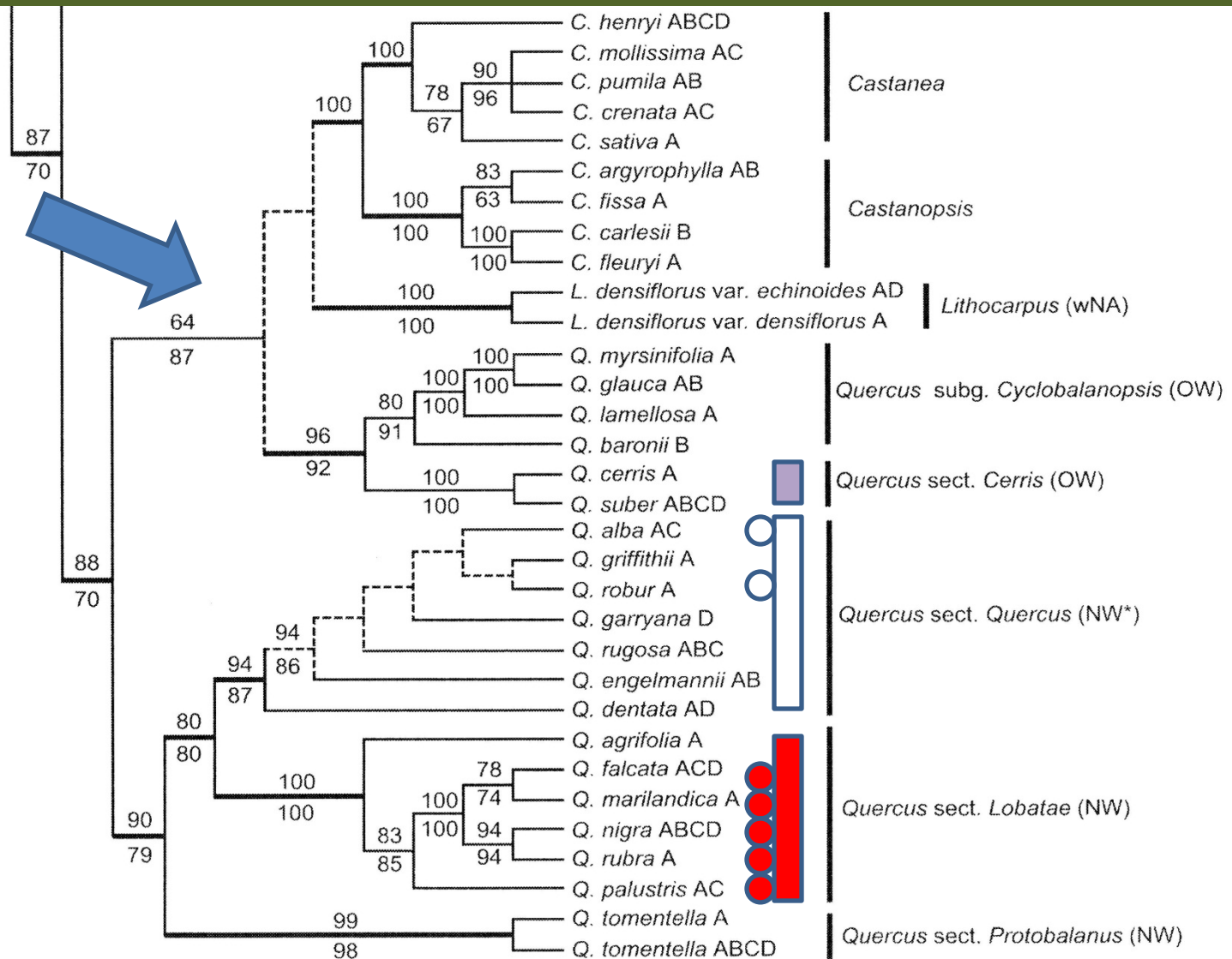


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# The future

**The molecules are wide open for research on the relationships of the North American white, red and intermediate oaks, and sorting out all the hyperbole of hybridization**

**No more**