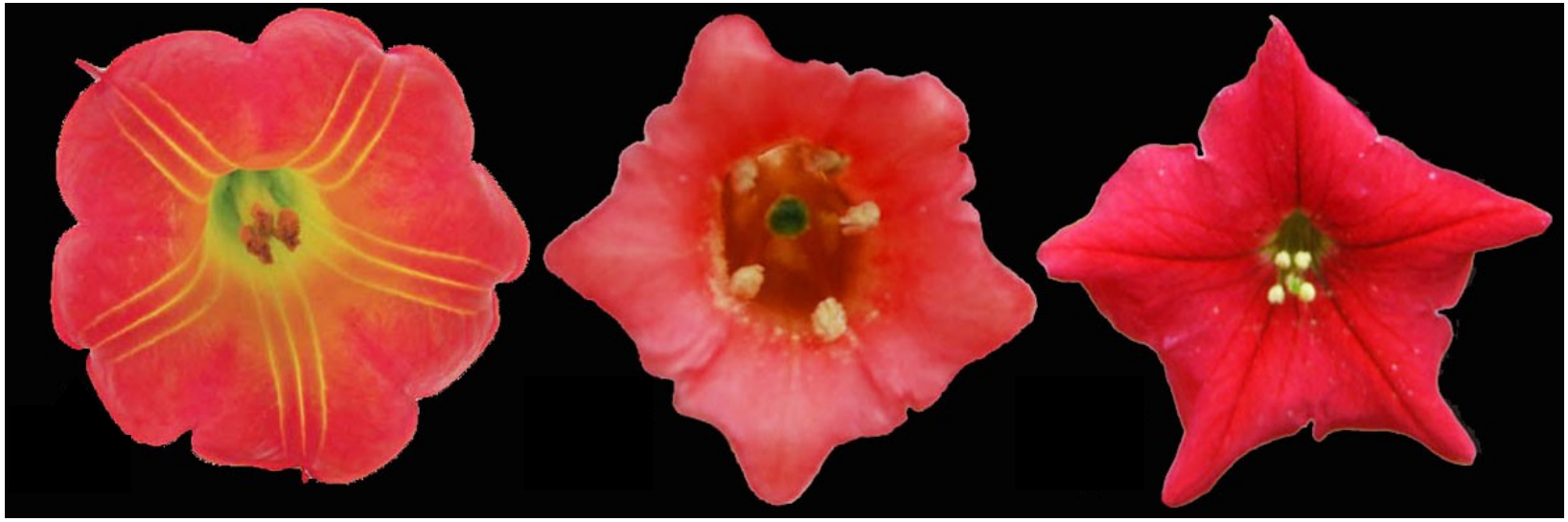
# How to make a flower color: do red flowers make red pigments?



Julienne Ng & Stacey Smith

University of Colorado **Boulder**

# Flower color diversity

# Flower color pigments

Anthocyanins

Carotenoids

Betalains

# Pigments & red flower color evolution


S. Shebs


T. Bradshaw

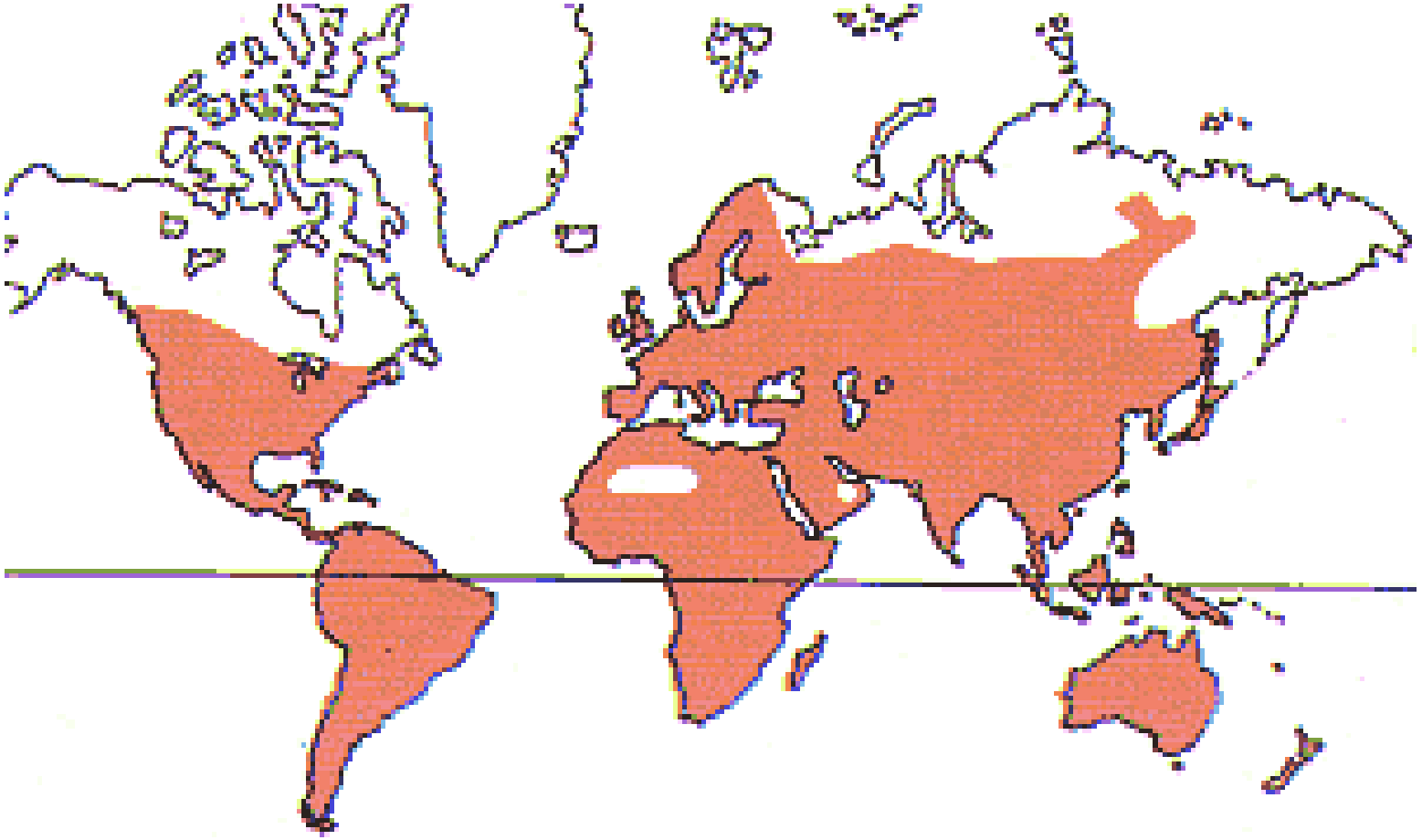

M. Bartkowska


M. Dubler

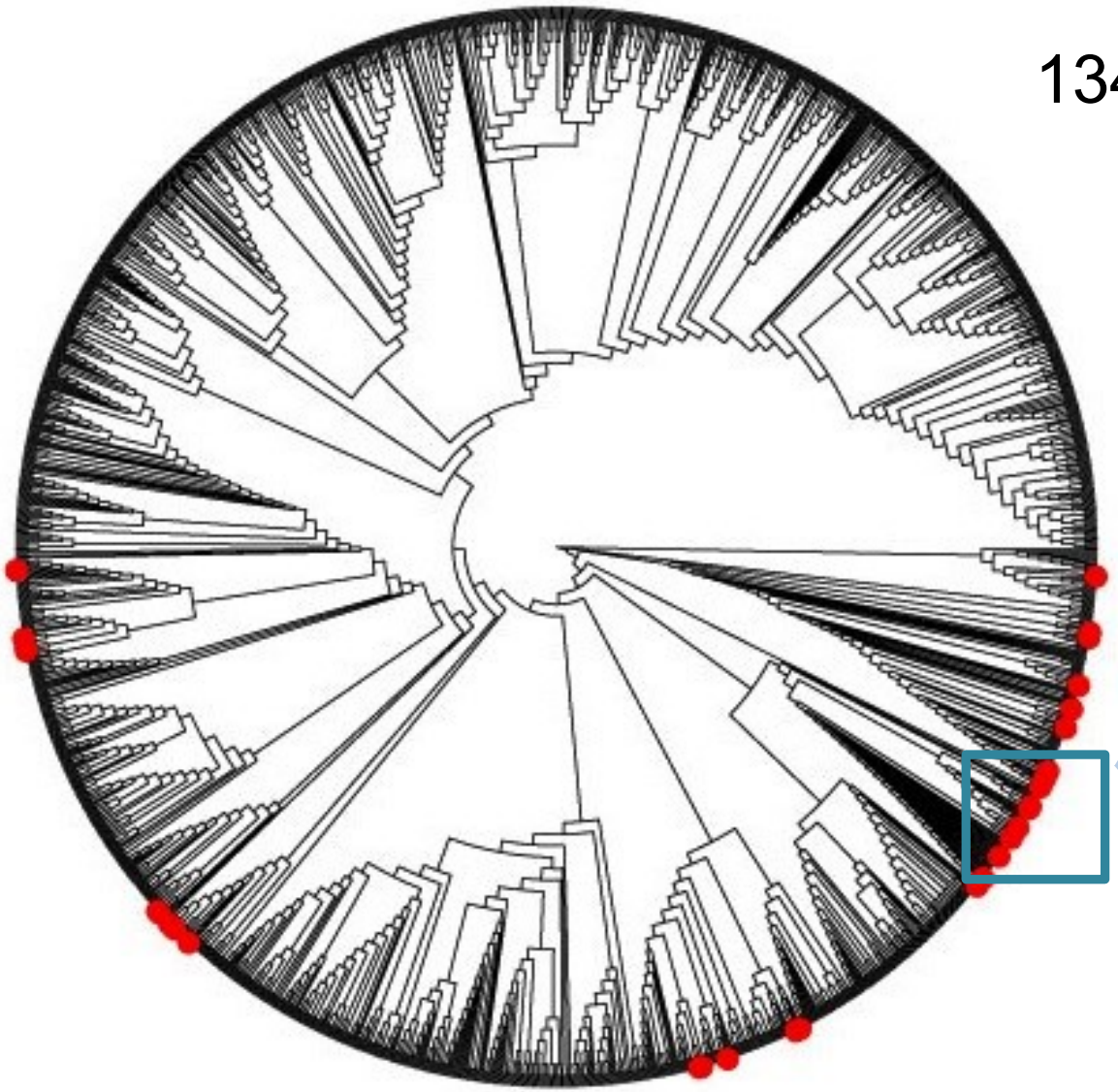
# Red flowers in Solanaceae

~2700 Solanaceae species
34 red flowered species

# Solanaceae distribution

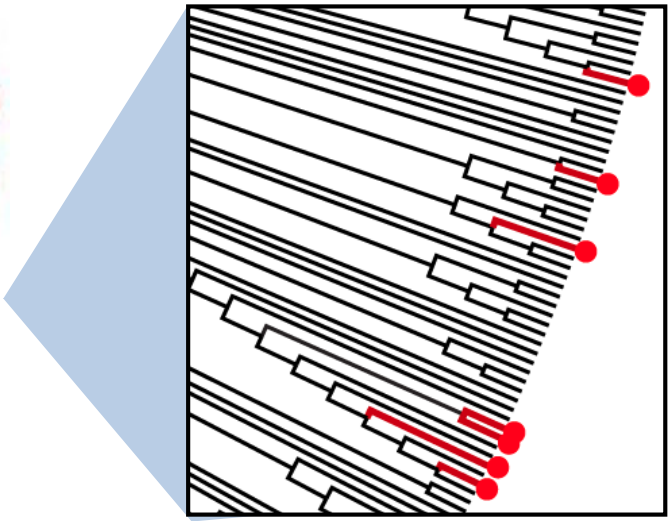


# Red flowers have evolved multiple times in Solanaceae



1341 species (~50% total)
33 of 34 red species

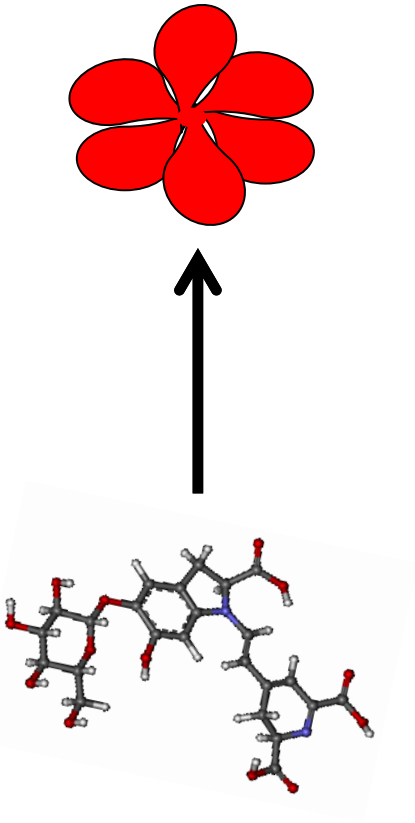
Evolved > 30 times



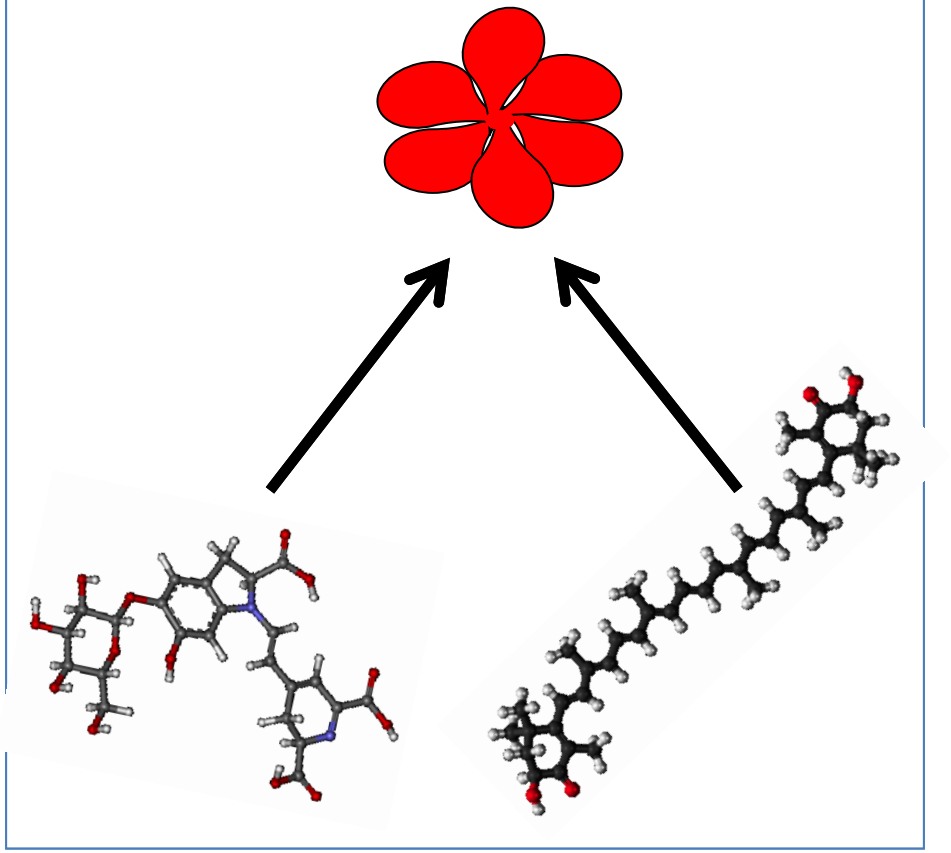
Ng and Smith, 2015 New Phytologist

# Are the same pigments used to make red flowers?

**Same pigment**



**Different pigments**



# Same color using different pigments

Anthocyanins







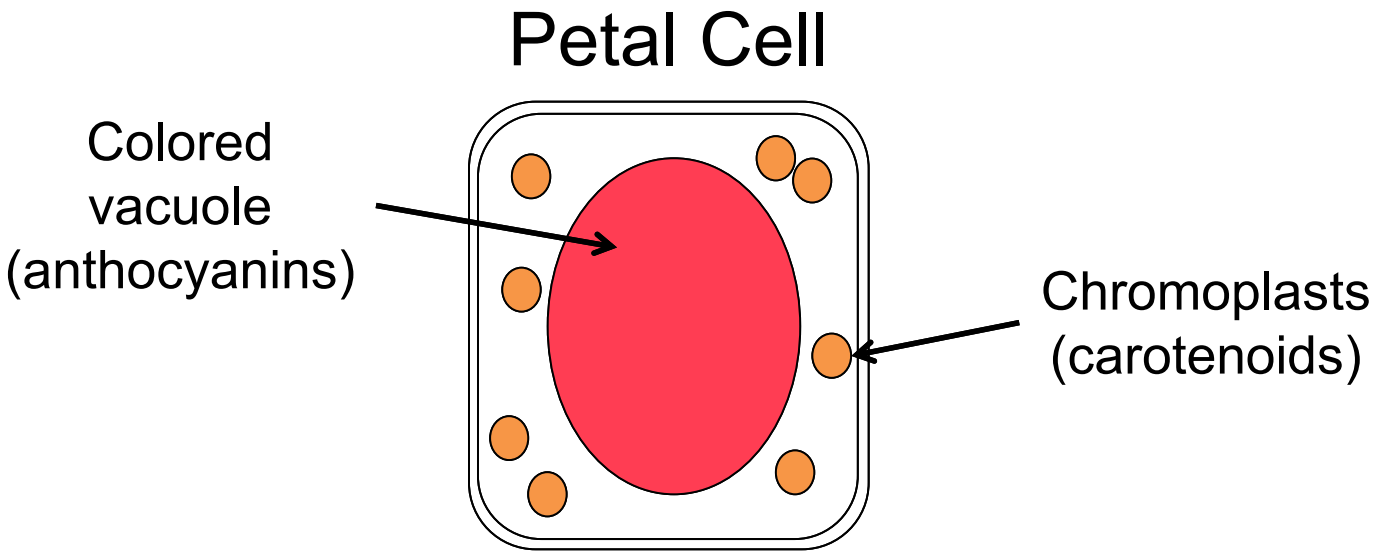

Carotenoids



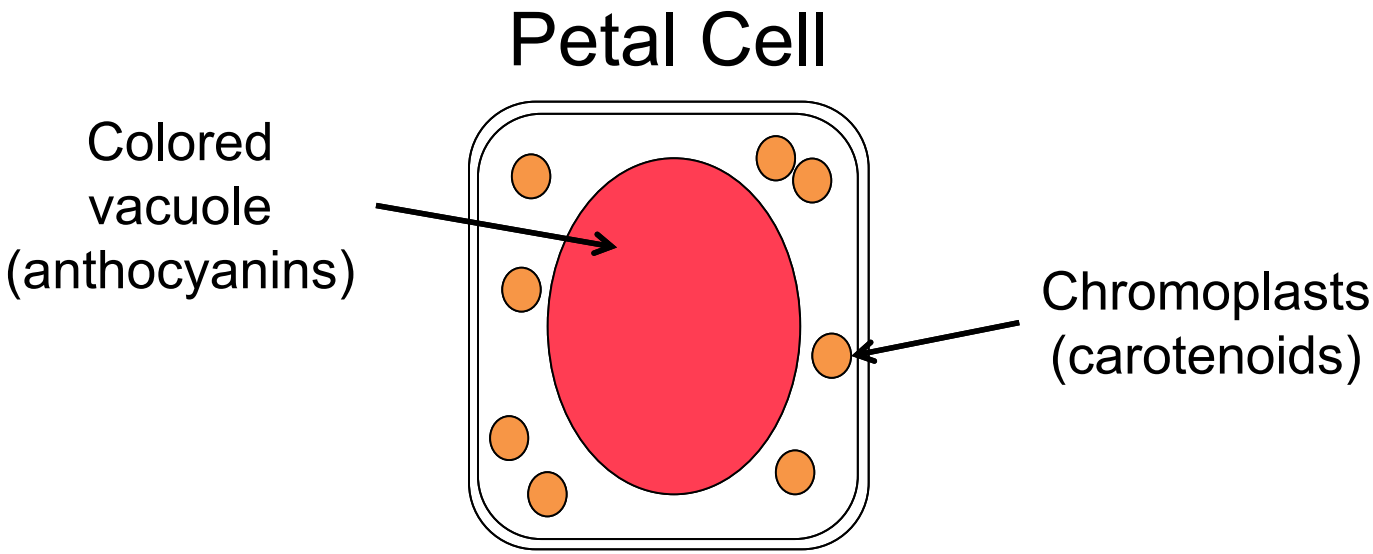


Betalains

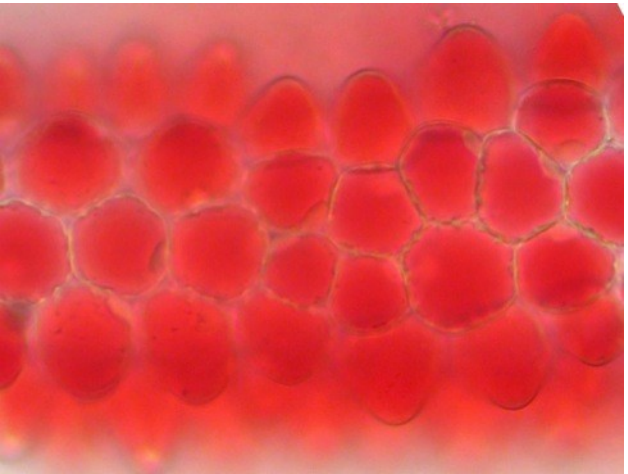
# Identifying the pigments used to make red flowers



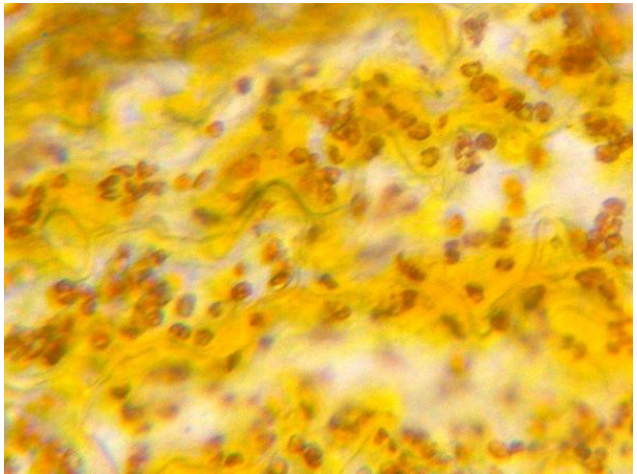
# Identifying the pigments used to make red flowers




Anthocyanins

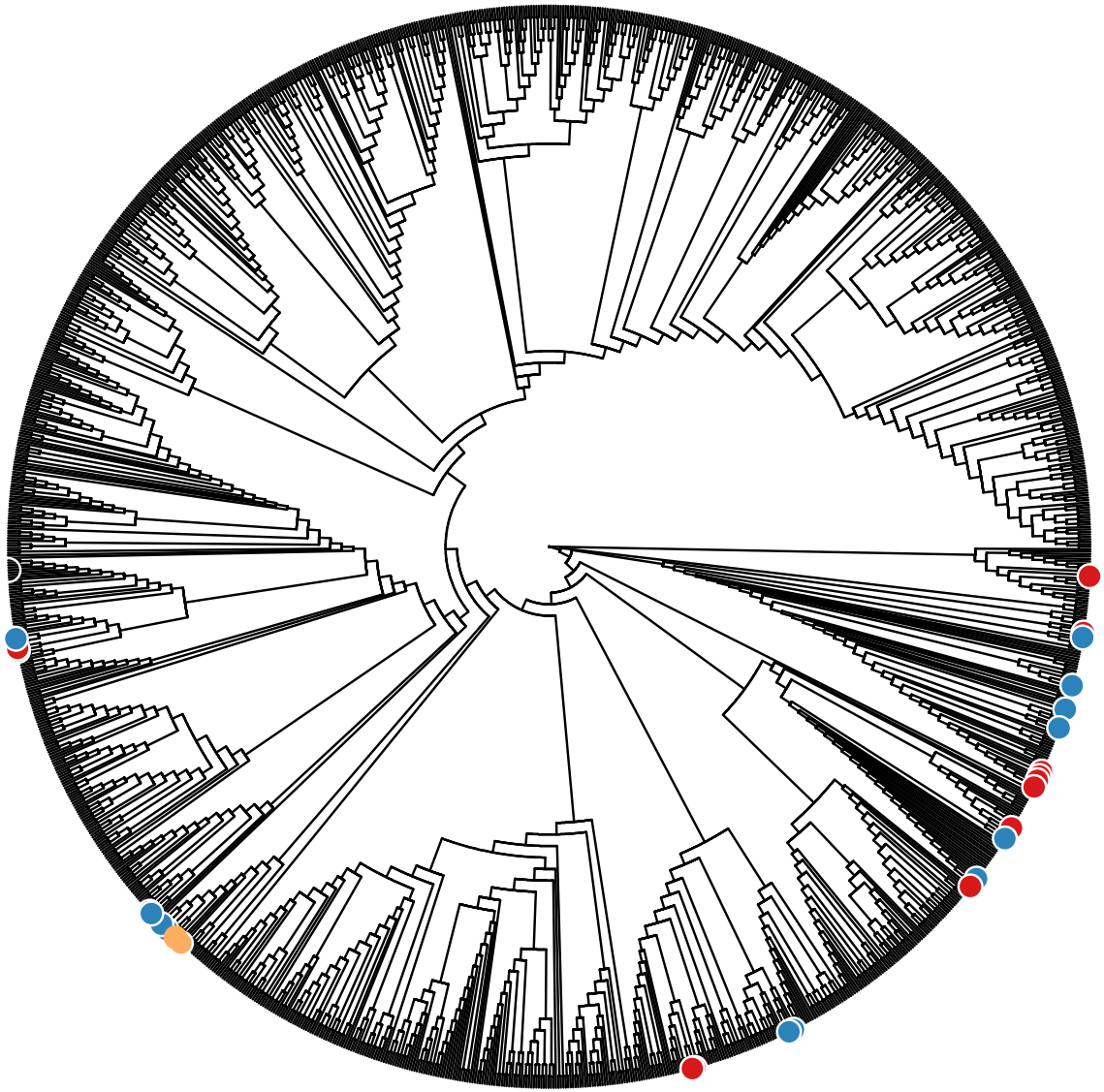


Carotenoids



Dual production

# Different pigments & pigment combinations make red flowers



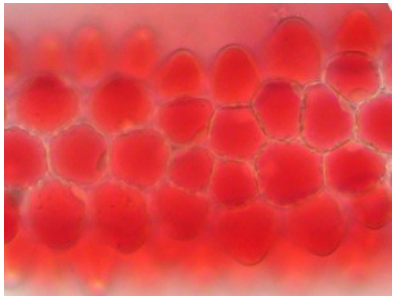
27 species scored:

- Anthocyanins (14 species)
- Carotenoids (2 species)
- Dual production (11 species)

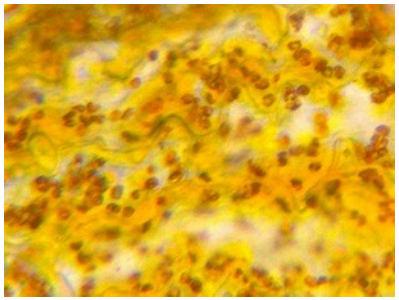
Ng and Smith, 2015 New Phytologist

# Do different pigments make the same red?

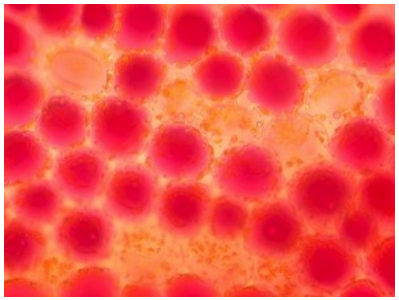
Anthocyanins

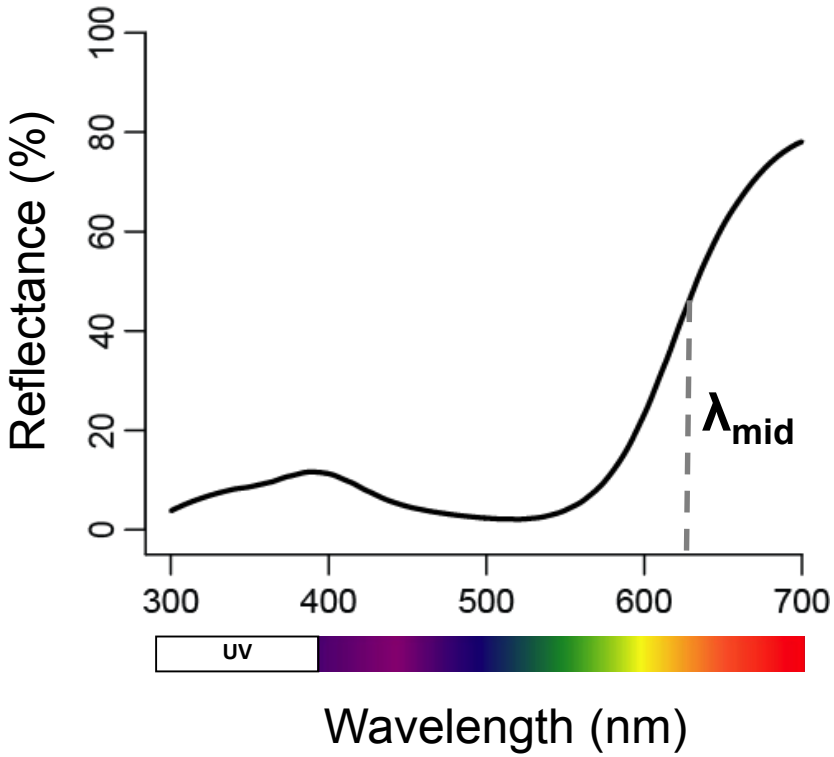


Carotenoids

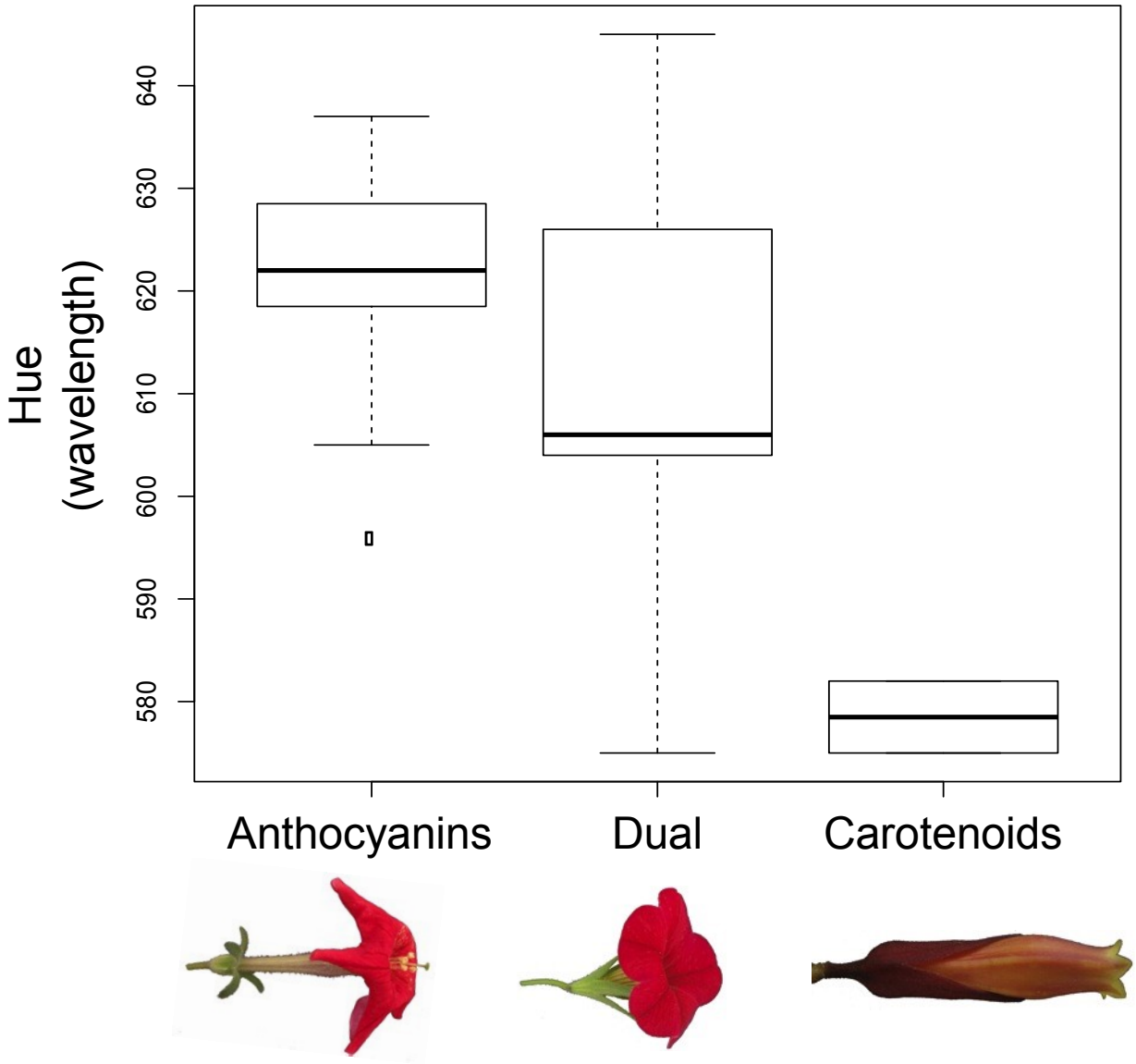


Dual

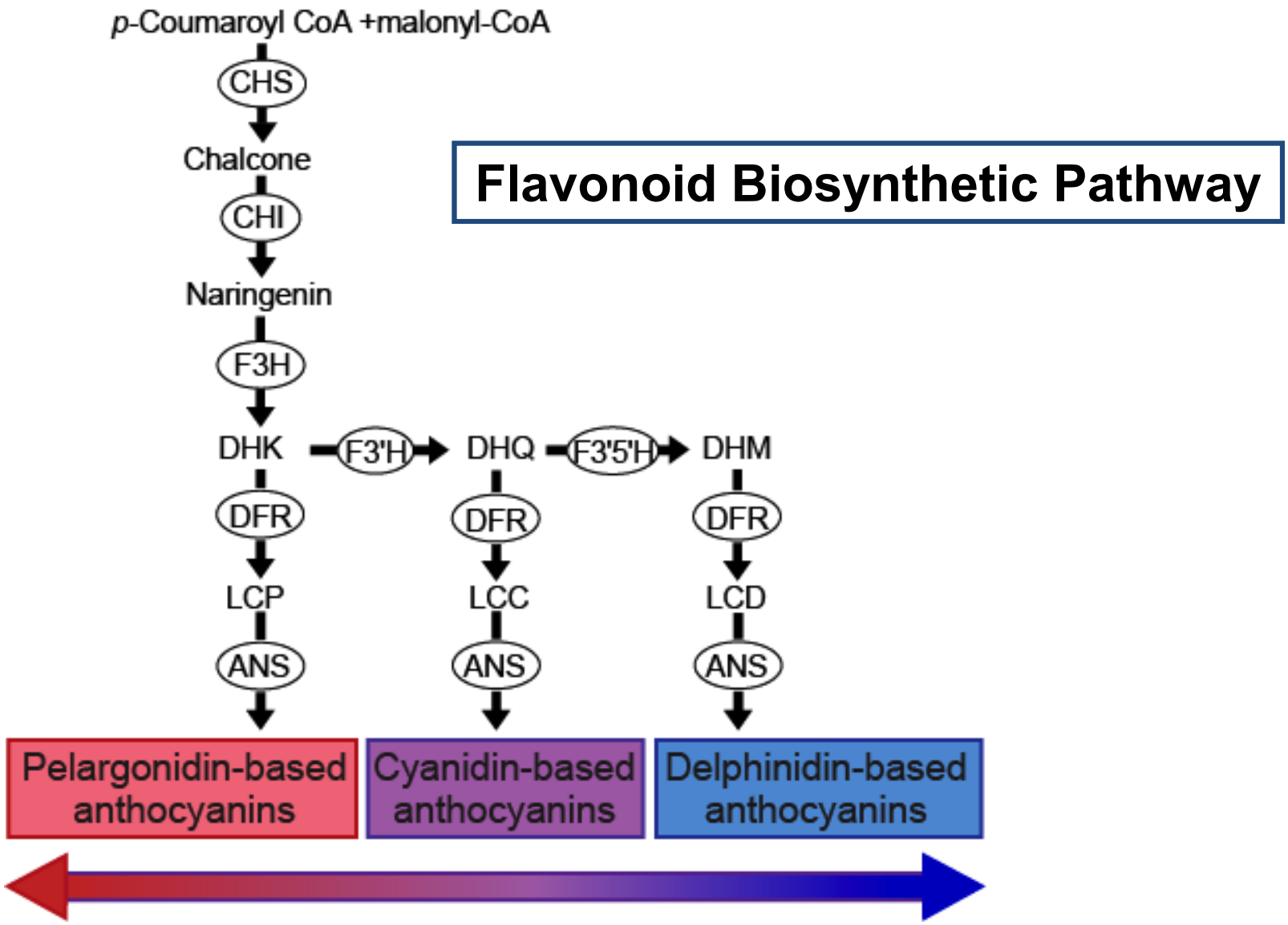




# Two of three strategies make the same red coloration



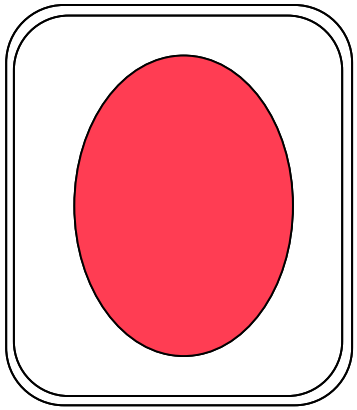
# Anthocyanin pigments



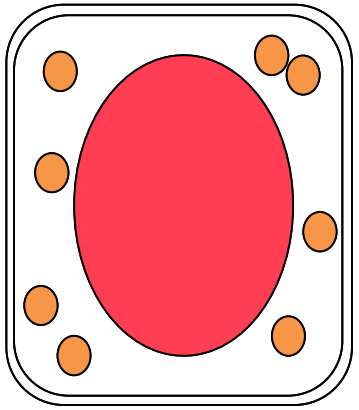
# Are the same anthocyanins being used?

Same classes of anthocyanins

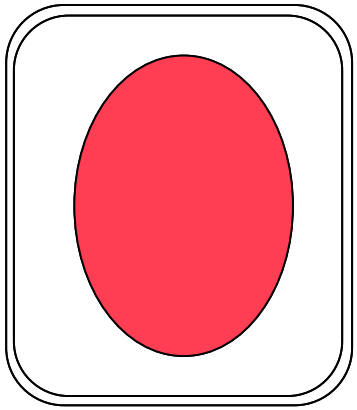
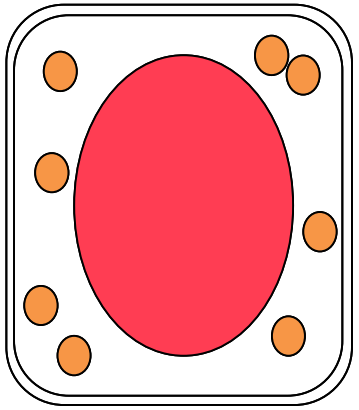
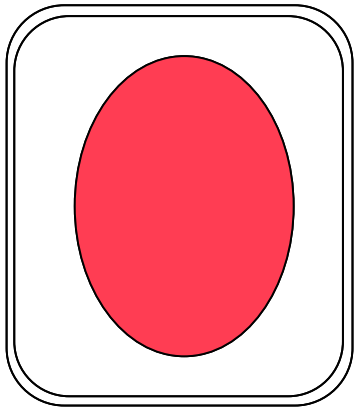
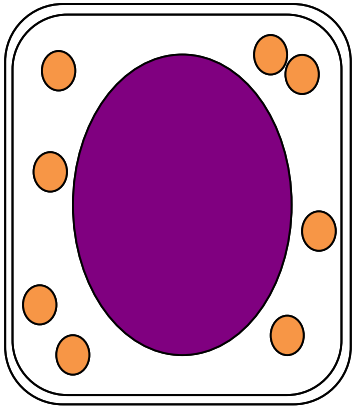
Sole anthocyanins



Dual production



# Are the same anthocyanins being used?

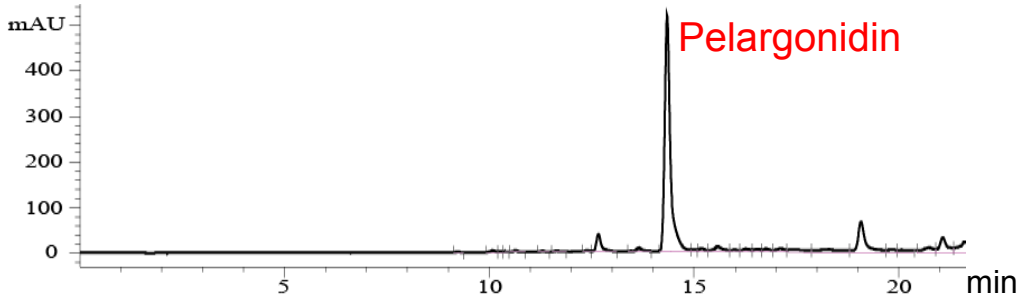
| | Sole anthocyanins | Dual production |
|---|---|---|
| Same classes of anthocyanins |  |  |
| Different classes of anthocyanins |  |  |

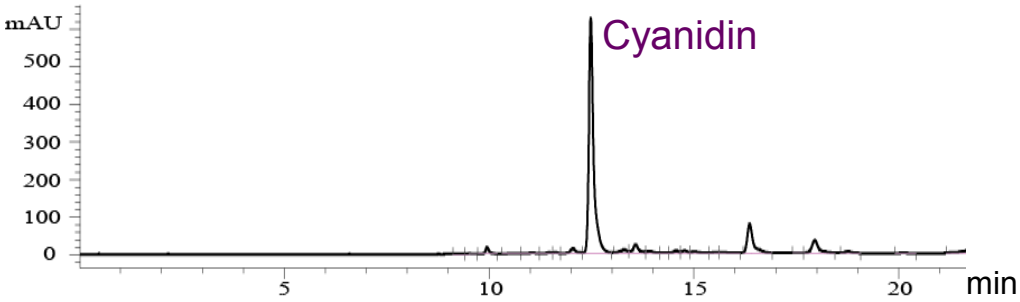
# Identifying anthocyanins using HPLC

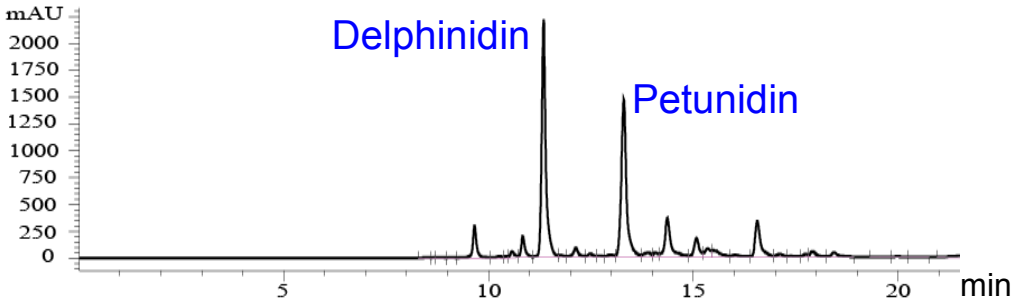
*Plowmania nyctaginoides*

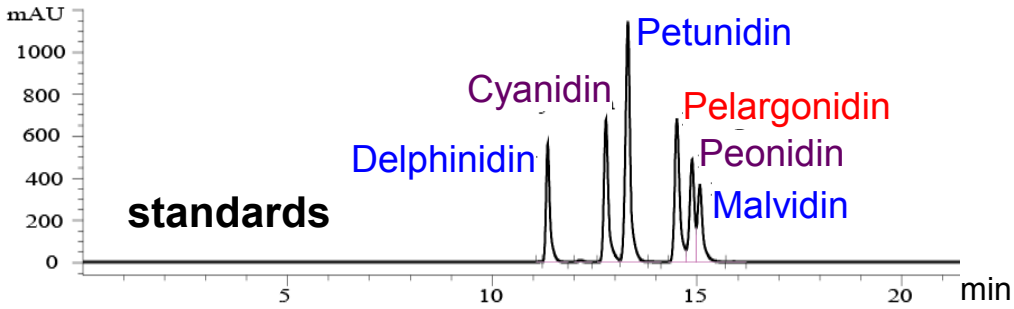
*Brugmansia sanguinea*

*Calibrachoa parviflora*

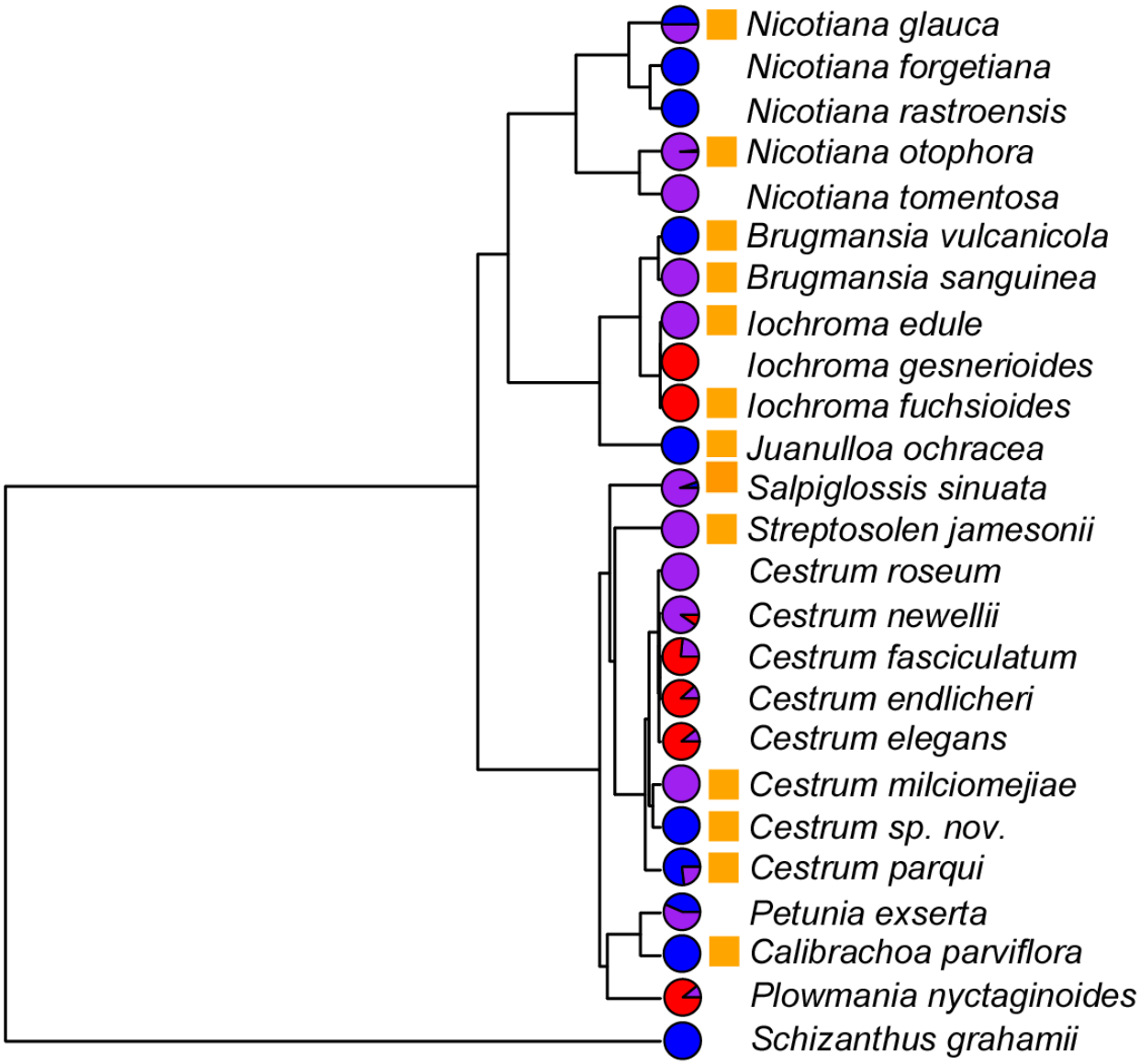


# Different anthocyanins are used when carotenoids are present




**Anthocyanin type**

Pelargonidin-based

Cyanidin-based

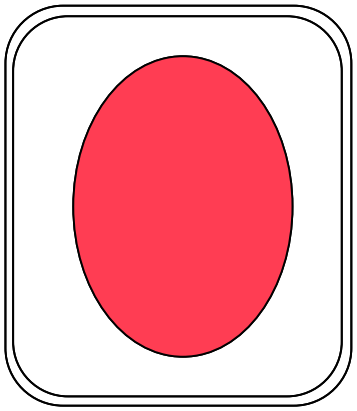
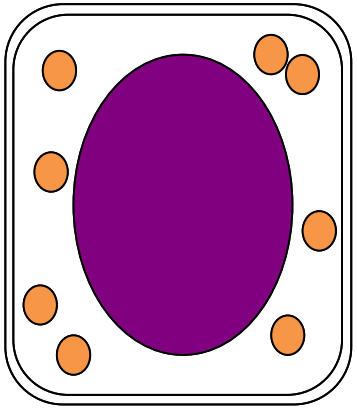
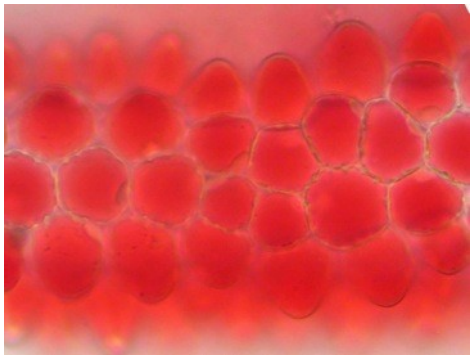
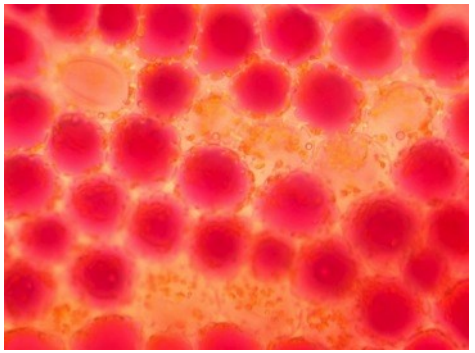
Delphinidin-based

**Dual production**

Carotenoids

# Red flowers repeatedly use the same strategy

Different classes of anthocyanins

| Sole anthocyanins | Dual production |
| --- | --- |
|  |  |
|  |  |
| Red or mix of red and other anthocyanins = red flower | Purple and blue anthocyanins + orange carotenoids = red flower |

# Exceptions point to other strategies

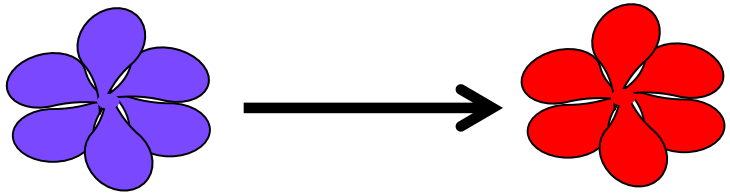
*Cestrum roseum*

all cyanidin-based anthocyanins

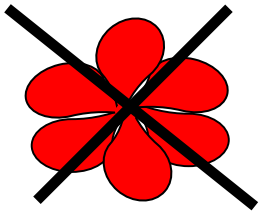
- Other flavonoid co-pigments
- Vacuolar acidification
- Cell shape

# Future research directions

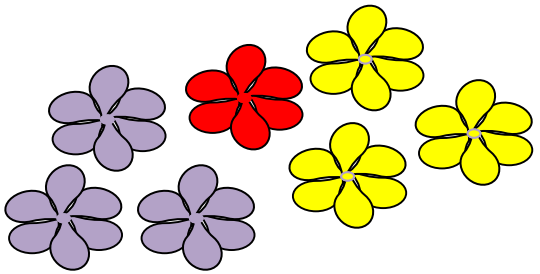
- How do red flowers evolve?



- Why are red flowers rare?



or



# Thank you!

**Smith Lab**

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Hanna Biagini-Lee
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Julia Dupin
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Jeff Neiman
Keric Lamb
Mandy Malone

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**Collaborators**

Richard Olmstead
Lynn Bohs
Loreta Freitas

**Funding**


Visit us at www.colorado.edu/smithlab