# BROKEN COLOUR AND VARIATIONS

Chuck Chapman

Greenhouse used for breeding as many iris from warm climates don't do well outside in my Agricultural zone 4a

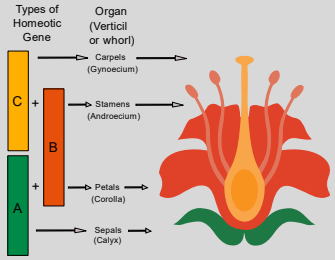
Inside unheated greenhouse I have equivalent to Oregon growing conditions and season

## History

## Cold Development

## Frost

## ABC of Flowers

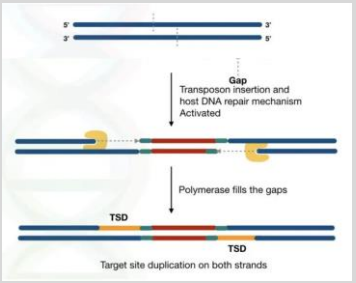



## Roundup

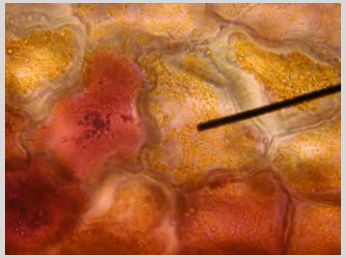
## Virus

## Chimera

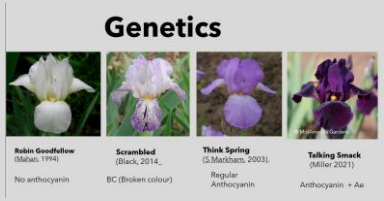
## Transposon




## Anthocyanin Inclusions



## Genetics




## BC Plicata

## Broken BC

## BC non-plicata

# Definition

An uneven and irregular random distribution of colour with each flower different in pigment distribution

Controlled genetically, not by disease or chemical

Not a developmental ‘one off’ error as in chimera

# History


**Victorine** (Lémon, 1840)

**Loreley** ( Goos and Koenemann, 1909)


**Japanesque** TB (Bernard Farr 1922)

**Kaleidoscope**
(Katkamier, R. 1929)


**W. R. Dykes** TB
( Dykes 1926)

**Joseph's Coat**
(Katkamier 1930)


**Corsage** TB
(Watkins 1955)

**Humoresque** TB
(Keppel 1962)

**Minnesota Mixed Up Kid**
IB unknown
In circulation in 1970's

# Allan Ensminger

1912-2010


Allan was the first person to undertake a successful breeding program with broken colour iris.

He asked people to send to him any broken colour cultivars and undertook a breeding program with them. Also sought out variable foliage cultivars

He registered approximately 25 BC cultivars that has proven to be the foundations of very many of the BC iris registered

He sent out collections of un-named cultivars to hybridizers to use in breeding .


**Dominocus** TB (Ensminger 1974)


**Doodle Strudel** TB (Ensminger 1977)

**Batik** BB (Ensminger, 1986

**Autumn Years** TB (Ensminger 1996)


**Brindled Beauty** TB (Emsminger 1994)

**Maria Tormena** TB (Emsminger 1987)

**Batik** BB (Ensminger 1986)


**Isn't This Something** (Ensminger 1993)


**Painted Plic** TB (Ensminger 1993)


**Peach Jam** TB (Ensminger 1989)


**Purple Streaker** TB (Ensminger 1981)

**Very Varied** BB (Ensminger 1993)

# Brad Kasperek

1945-2022

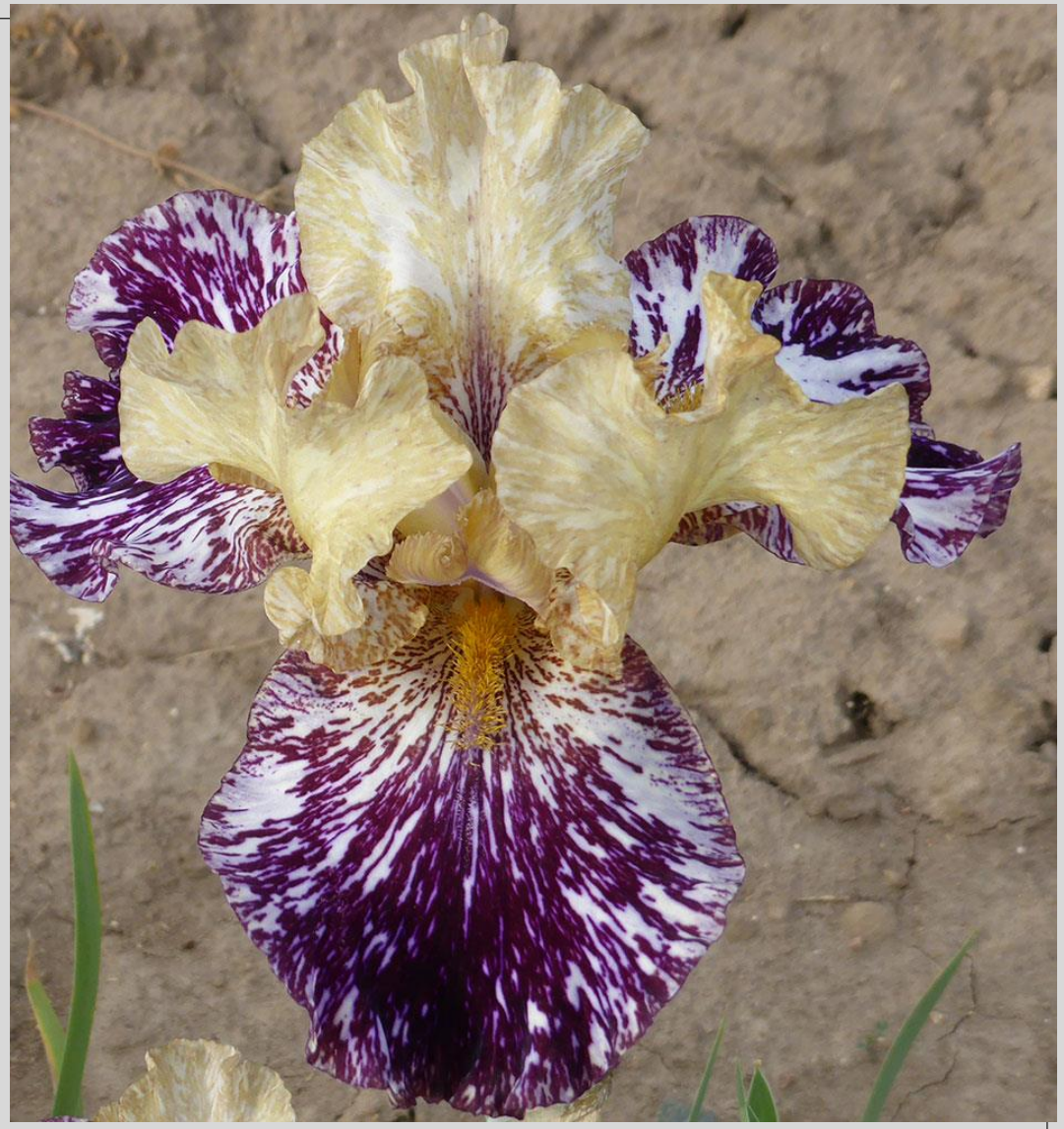

**Millenium Falcon** TB (Kasperek 2000)

**Bewilderbeast** TB (Kasperek 1995)


**Baboon Bottom** BB (Kasperek 1994)

**Tiger Honey** TB (Kasperek 1994)

**Anaconda Love** BB (Kasperek 1999)



**Gnu's Flash** TB (Kasperek 1996)

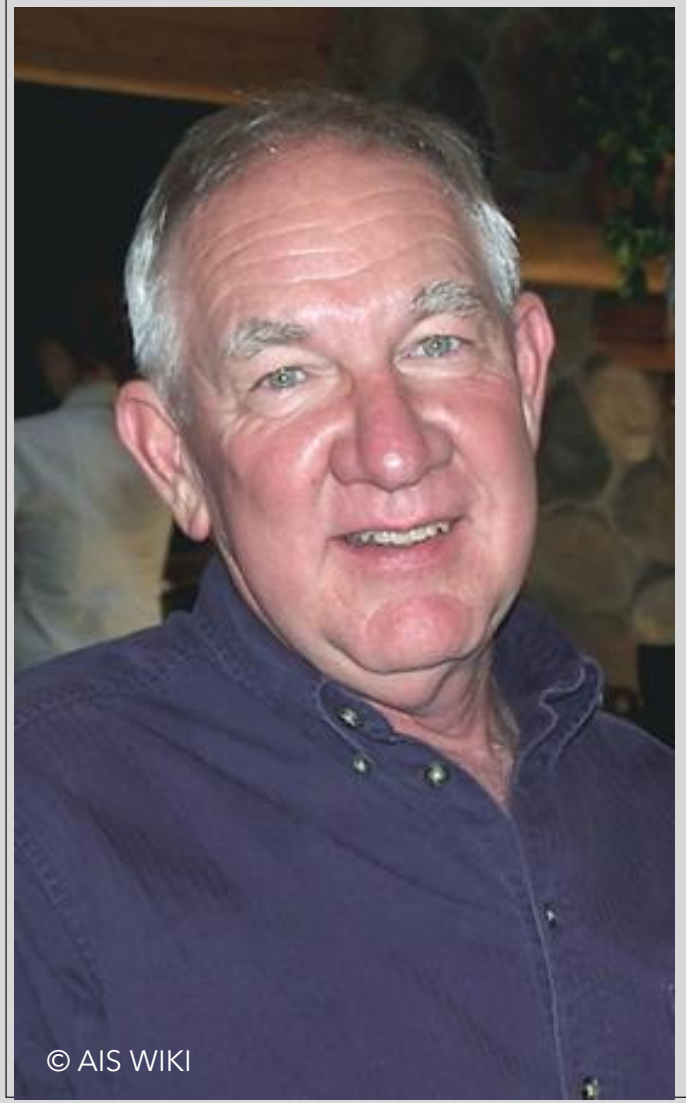

**Giraffe Kneehiz** TB
(Kasperek 1996)

**Kinkajou Shrew** TB
(Kasperek 1999)


**Flamingo Gringo** TB (Kasperek 2008)


**Spiced Tiger** TB (Brad Kasperek 1996)

# Paul Black





**Wizard Of Odds** TB (Black 2009)

**Big Break** TB (Black 2017)


**Seek The Unique** TB (Black 2020)

**Die Laughing** TB (Black 2014)


**Wild Streak** TB (Black 2020)


**Zip Zing Zowie** TB (Black 2021)

**Broken Pattern** TB (Black 2004)


**Break In** TB (Black 2019)


**I'm Not Stable** TB (Black 2020)

# George and Mike  Sutton

**Peggy Anne** TB ( G Sutton 2007)

George
1933-2013



**Silver Streak** TB ( M Sutton 2006)


**Purple Marble** TB (M Sutton 2021)


**Break The Barrier** TB (M Sutton 2024)


**Broken Record** TB (M Sutton 2005)

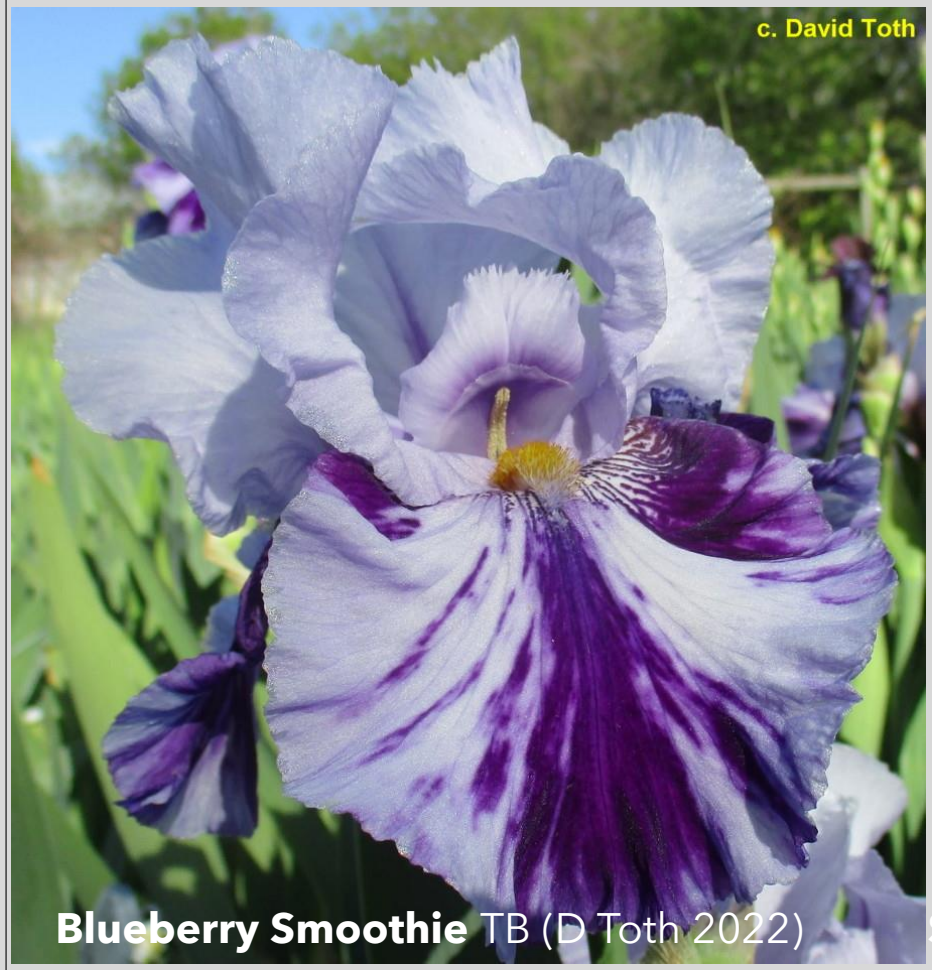

**Break It Up IB** (M Sutton 2022)



**Spiced Up** TB (M Sutton 2022)

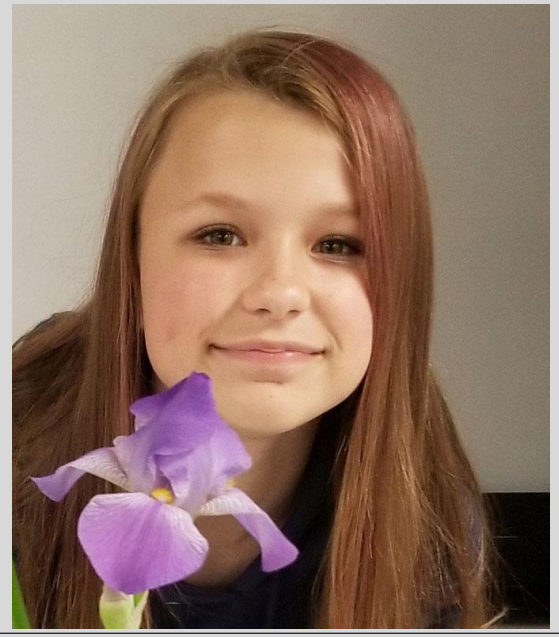
TB seedling  Spiced Up X Cowboy Boots M. Sutton

# David and Ava Toth




**Blueberry Smoothie** TB (D Toth 2022)


**Sheer Panic** TB (D Toth 2019)




**Early Morning Rayz** TB
(D Toth 2019)


**Exceeding Expectations**
TB (D Toth 2022)


**Jelly Splatter** TB (D Toth 2021)


**Abstract Dreams** TB (D Toth 2019)


**Krakatoa Katie** TB (D Toth 2019)


**Shattered Illusions** IB (D Toth 2022)


**Havana  Cabana** IB (A Toth 2021)


**Makin' Lemonade**  IB (Ava Toth, R. 2024).


**Sleep Deprived** IB (Ava Toth 2021)


**Butter Not Try It'** (Ava Toth, R. 2022)

# Frost Damage

Usually affects texture and form

But can affect colour

And can produce irregular colours



**Power Down** TB (Burseen 2015)

# Leopard Print SDB

**Spot expression is weather dependent**
**Most likely cold nights during bud development**

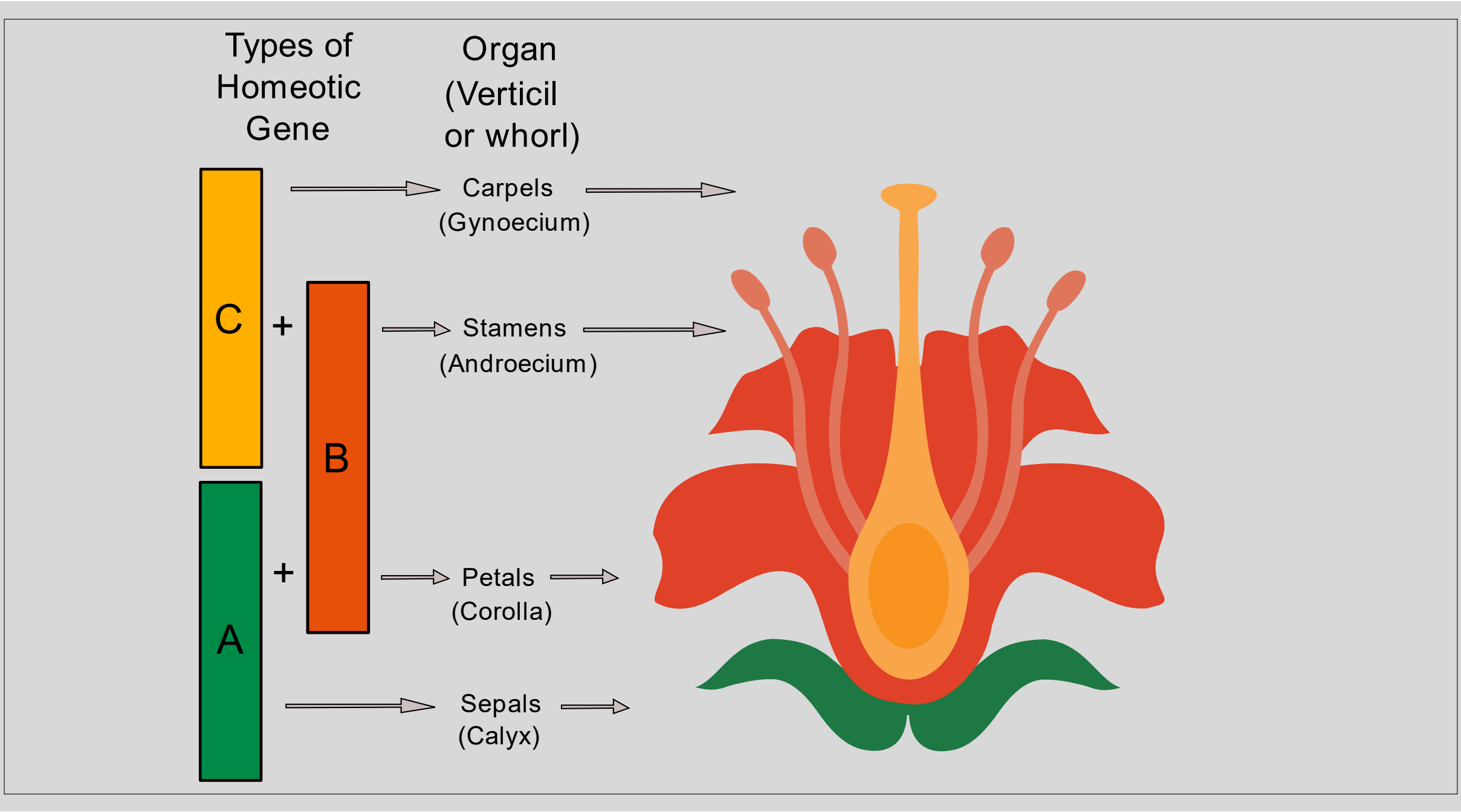
# Developmental Errors

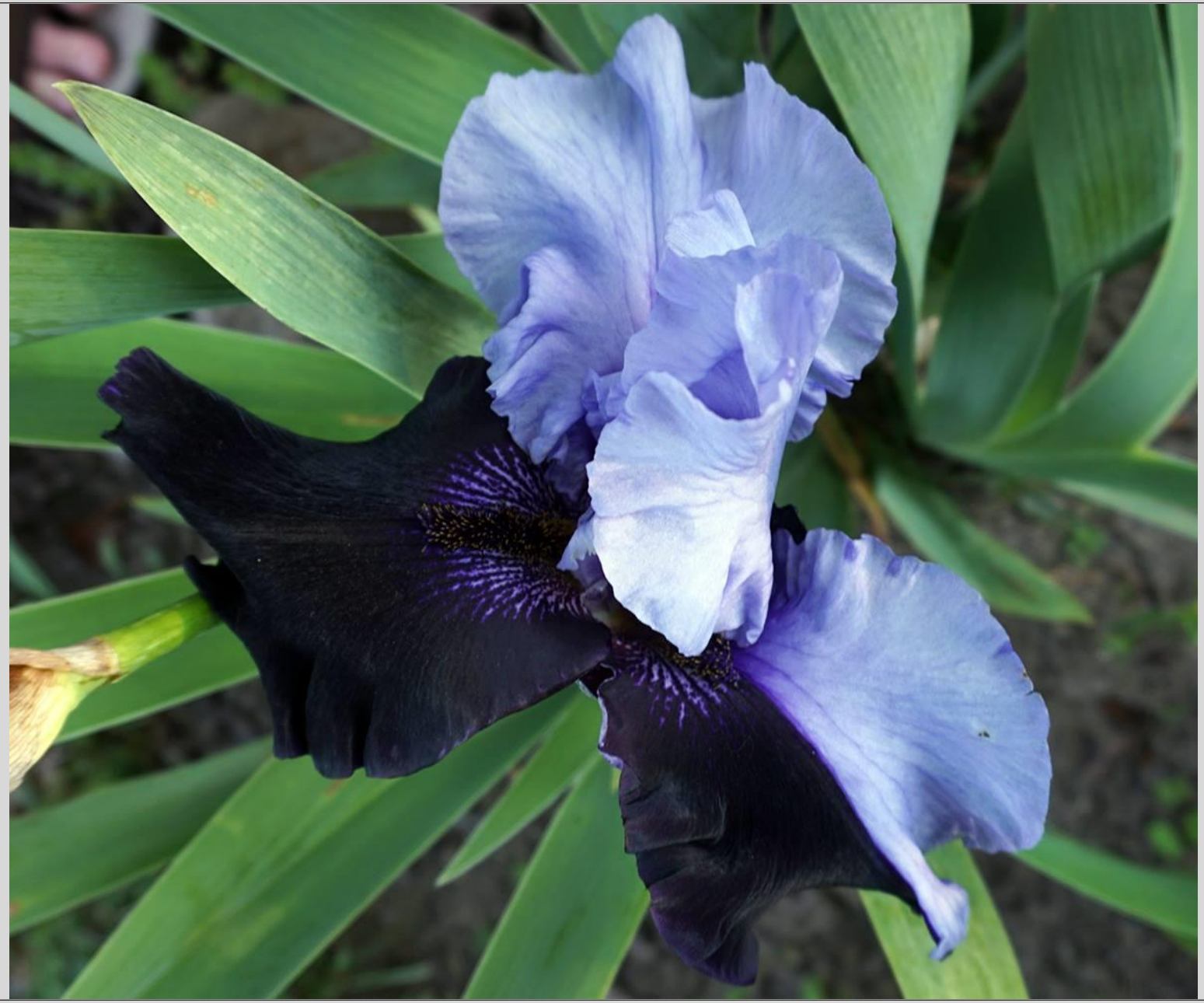
Petals and falls of iris are  often different in colour

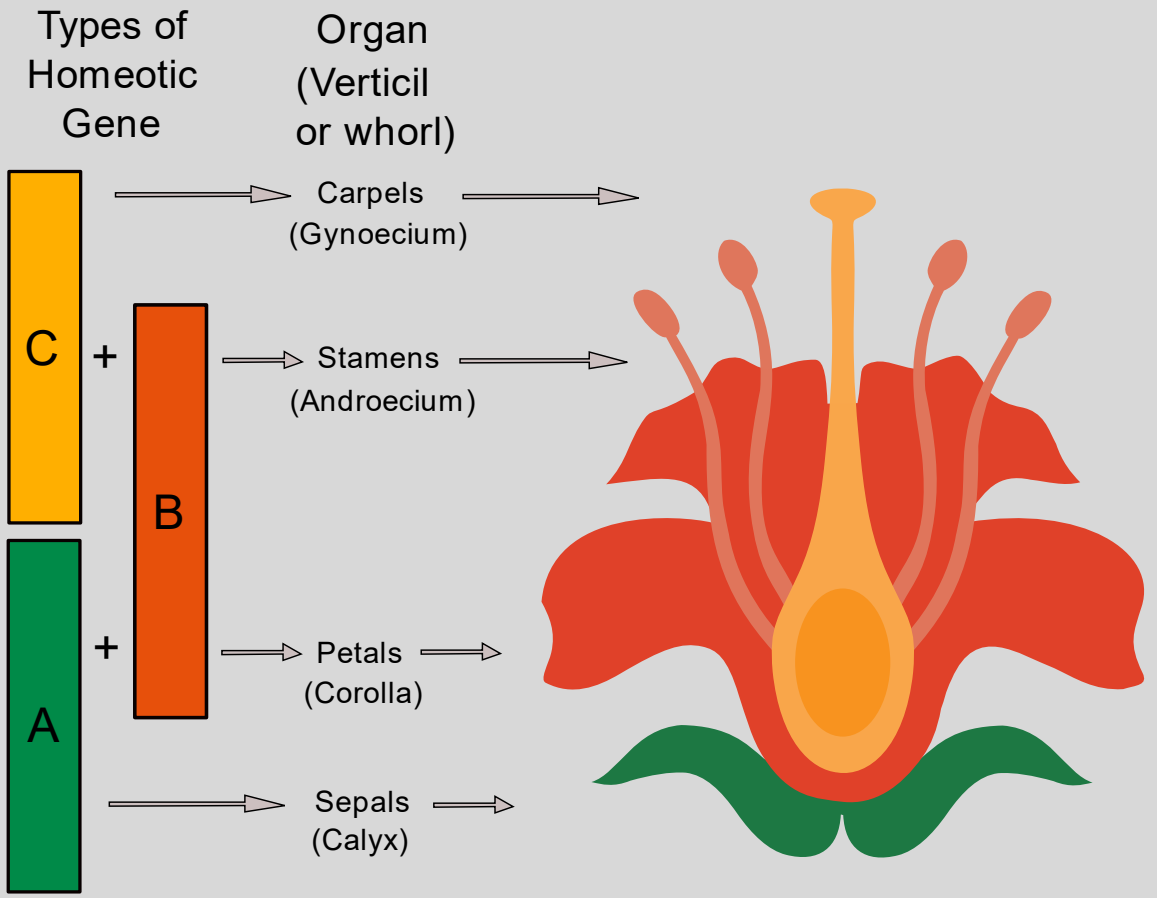
Developmental errors  can cause confusion in  flower parts

So sometimes  petals  can be identified as falls

And falls can be identified as petals


Types of Homeotic Gene
Organ (Verticil or whorl)
C
+
B
A
+
Carpels (Gynoecium)
Stamens (Androecium)
Petals (Corolla)
Sepals (Calyx)




Types of Homeotic Gene
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Petals (Corolla)
Sepals (Calyx)

**Untamed Glory  TB** (Johnson 2021)

**Why Be Normal**  (Johnson 2014)

# Mosaic Iris Virus

- https://pddc.wisc.edu/wp-content/blogs.dir/39/files/Fact_Sheets/FC_PDF/Iris_Severe_Mosaic.pdf

Extension
UNIVERSITY OF WISCONSIN-MADISON

**Provided to you by:**

University of Wisconsin

## Iris Severe Mosaic

Derrick Grunwald and Renee Rioux, UW-Madison Plant Pathology

**What is iris severe mosaic?** Iris severe mosaic (also called yellow latent disease or gray disease) is a potentially severe viral disease that can adversely affect both bulb and rhizome-forming irises, as well as crocuses. German bearded irises are particularly susceptible to the disease. Commercially produced irises and crocuses affected by iris severe mosaic cannot be sold. Thus, iris severe mosaic can have potentially significant economic consequences for iris and crocus producers.

Pale green and yellow stripes on iris leaves are typical symptoms of iris severe mosaic.

Barnett, O. W., G. A. De Zoeten, and G. Gaard. "Bearded Iris Mosaic Virus: Transmission, Purification, Inclusions, and its." *pathology* 61 (1971): 926-932.

**At least 6 different mosaic virus infect iris**

Most active in lower temperatures

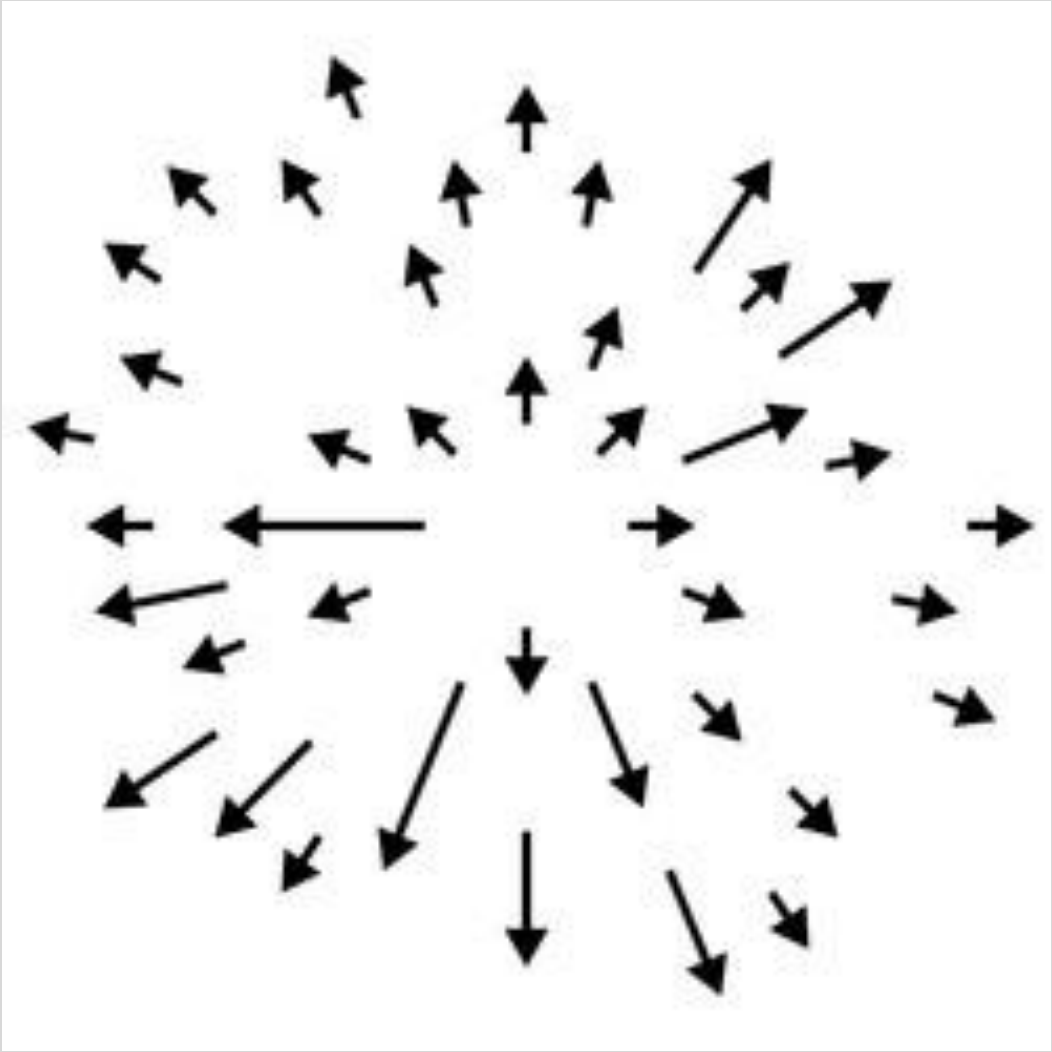

**Image Number:** 5505029

## Iris Severe Mosaic Virus (Potyvirus Iris Severe Mosaic Virus (ISMV))

| | |
|---|---|
| **Photographer:** | Anette Phibbs |
| **Organization:** | WI Department of Agriculture, Trade & Consumer Protection |
| **Descriptor:** | Symptoms |
| **Description:** | Iris spp. 'Fireplace Embers' |
| **Image type:** | Laboratory |
| **Host:** | iris (*Iris* L.) |

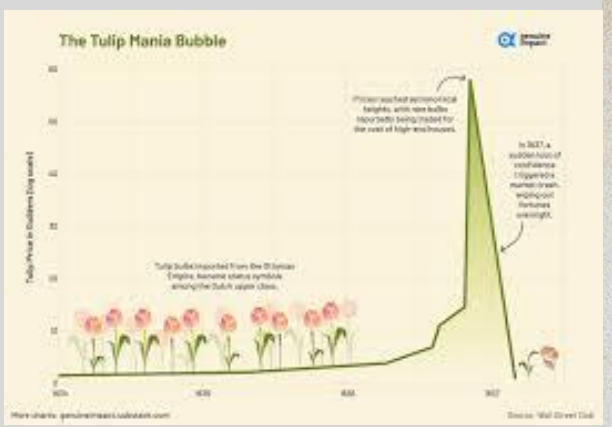
# Virus

radiates out  in all directions infecting neighbouring cells in a random pattern



# Tulip Mania

Holand 1634-1637




**Az Ap** IB (Ensminger 1980) HM 1982, AM 1984, Sass Medal 1987

# W. R. Dykes

TB (W. R. Dykes 1926)

This is an example of mosaic virus

Crepe texture and weak texture in many places in flower

Uneven edge on flower petals

Spots are random, not in any specific shape


# Genetic or Virus

- **Virus**
- Uneven  texture of petals  ie weak texture
- Spots have no margin
- Spots do not have triangle  shapes
- Petals have uneven and irregular  margins
- No reversions
- Shows less in warm weather

**Genetic control**

Has wedges

Passed on genetically

Even petal margins

Even texture  on petals

Weather has no effect on expression

BC can have virus
Iris with virus can have chimera

# Roundup (glyphosate)


Glyphosate acts by preventing production or aromatic amino acids.

These amino acids are basic building blocks of the anthocyanin pigments.

First symptom is reduction of anthocyanin pigment.

Higher dosages affect the form and size of the flower

Usually a temporary affect . Later flowers on stalk can be less affected and perhaps totally unaffected

Minor effects are often found attractive

The effects are distinctive and unique to Glyphosate

# Flower pigments in Iris

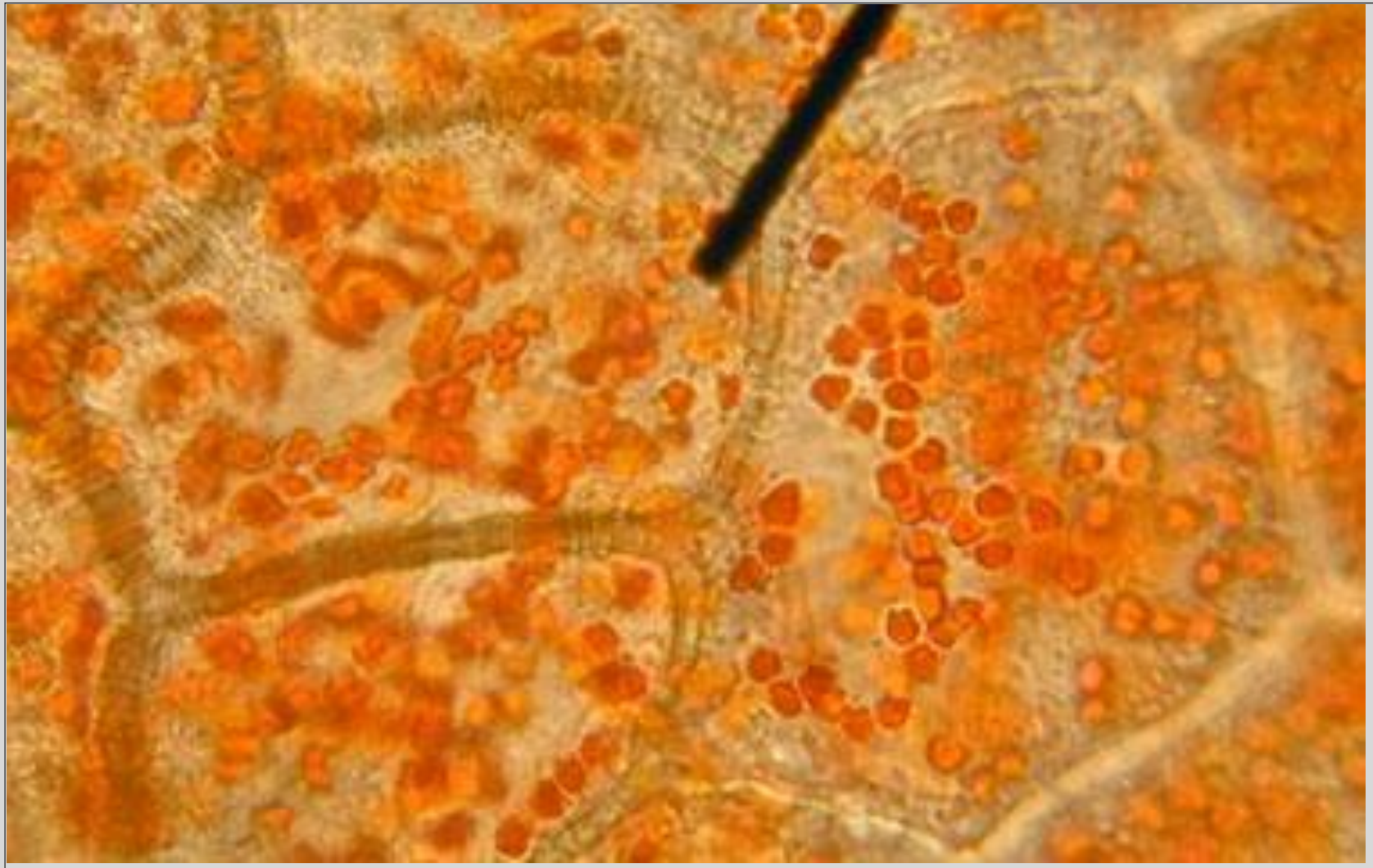
Two sets of pigments, Carotenoid and Anthocyanins

Each of these are located in different parts of plant cells

Carotenoid in cell wall in chromoplasts ( modified plastids)
Are oil soluble

Anthocyanins in cell vacuole, water soluble Delphinidin is anthocyanin present. Many different types, based on which and how many sugars attached

Each pigment system under different and independent genetic controls



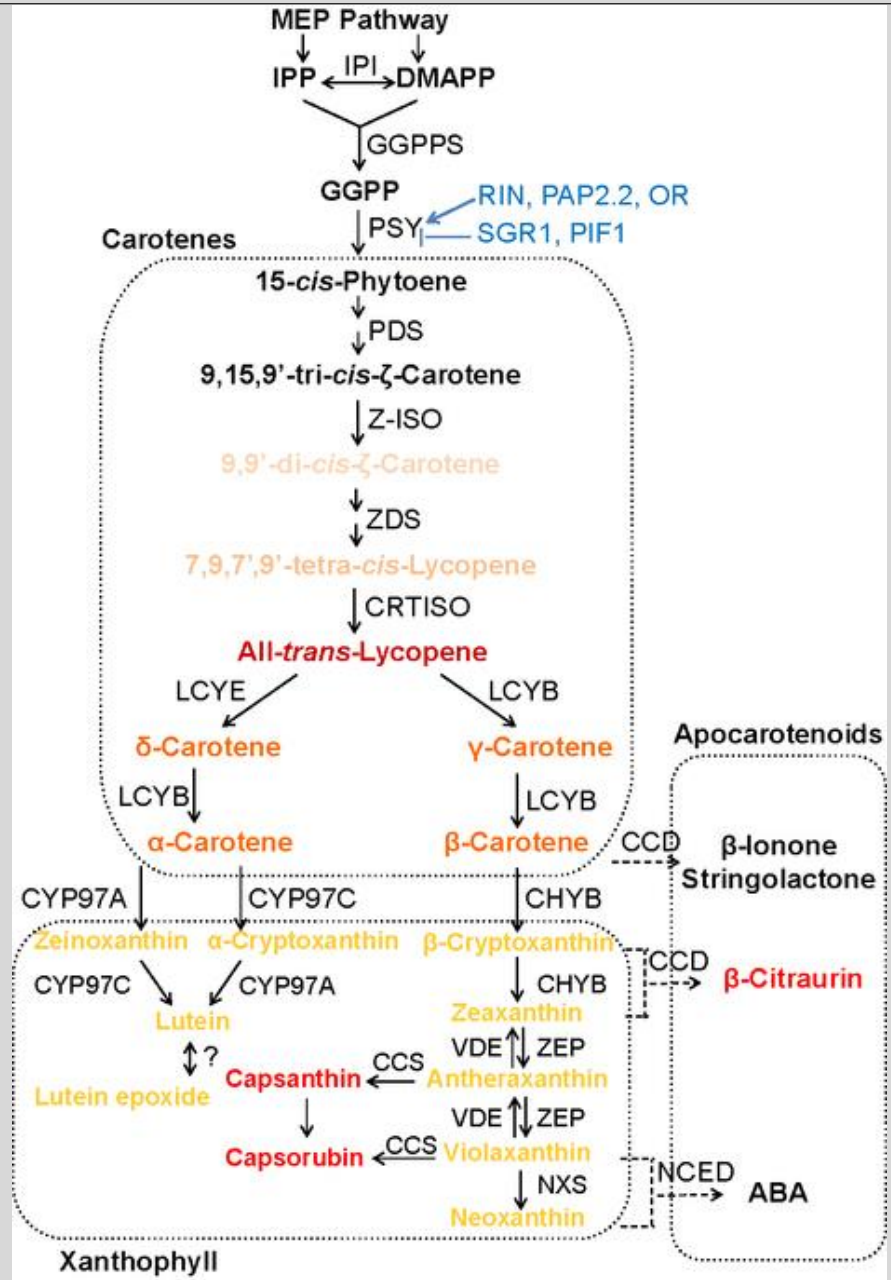
Chromoplasts are numerous

Located in cytoplasm of cell

Pigment in oil globules in chromoplasts

various Carotenoid pigments

**Chromoplasts in an iris flower** 1000 X magnification


MEP Pathway
IPP
IPI
DMAPP
GGPPS
GGPP
RIN, PAP2.2, OR
PSY
SGR1, PIF1
Carotenes
15-cis-Phytoene
PDS
9,15,9'-tri-cis-ζ-Carotene
Z-ISO
9,9'-di-cis-ζ-Carotene
ZDS
7,9,7',9'-tetra-cis-Lycopene
CRTISO
All-trans-Lycopene
LCYE
LCYB
δ-Carotene
γ-Carotene
LCYB
LCYB
α-Carotene
β-Carotene
Apocarotenoids
CCD
β-Ionone
Stringolactone
CYP97A
CYP97C
CHYB
Zeinoxanthin
α-Cryptoxanthin
β-Cryptoxanthin
CCD
β-Citraurin
CYP97C
CYP97A
CHYB
Lutein
Zeaxanthin
?
VDE
ZEP
Capsanthin
CCS
Antheraxanthin
Lutein epoxide
VDE
ZEP
Capsorubin
CCS
Violaxanthin
NXS
NCED
ABA
Neoxanthin
Xanthophyll









# Delphinidin

Blue pigment in iris is **Delphinidin**, a type of anthocyanin

A bluish purple , not a true blue

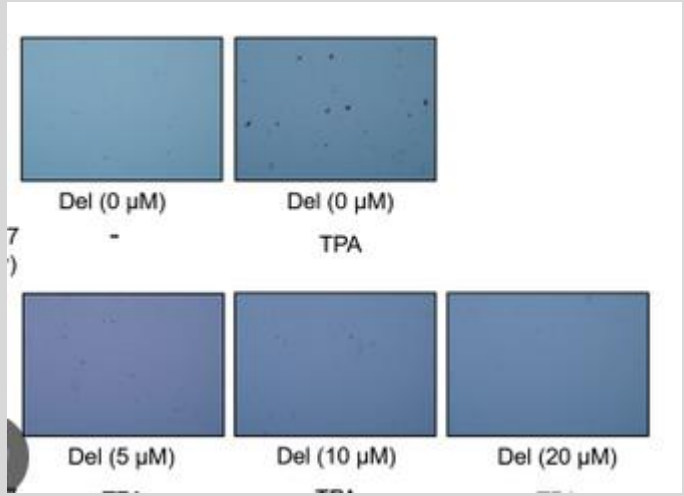
Delphinidin is darker in cold weather, particularly during bud development

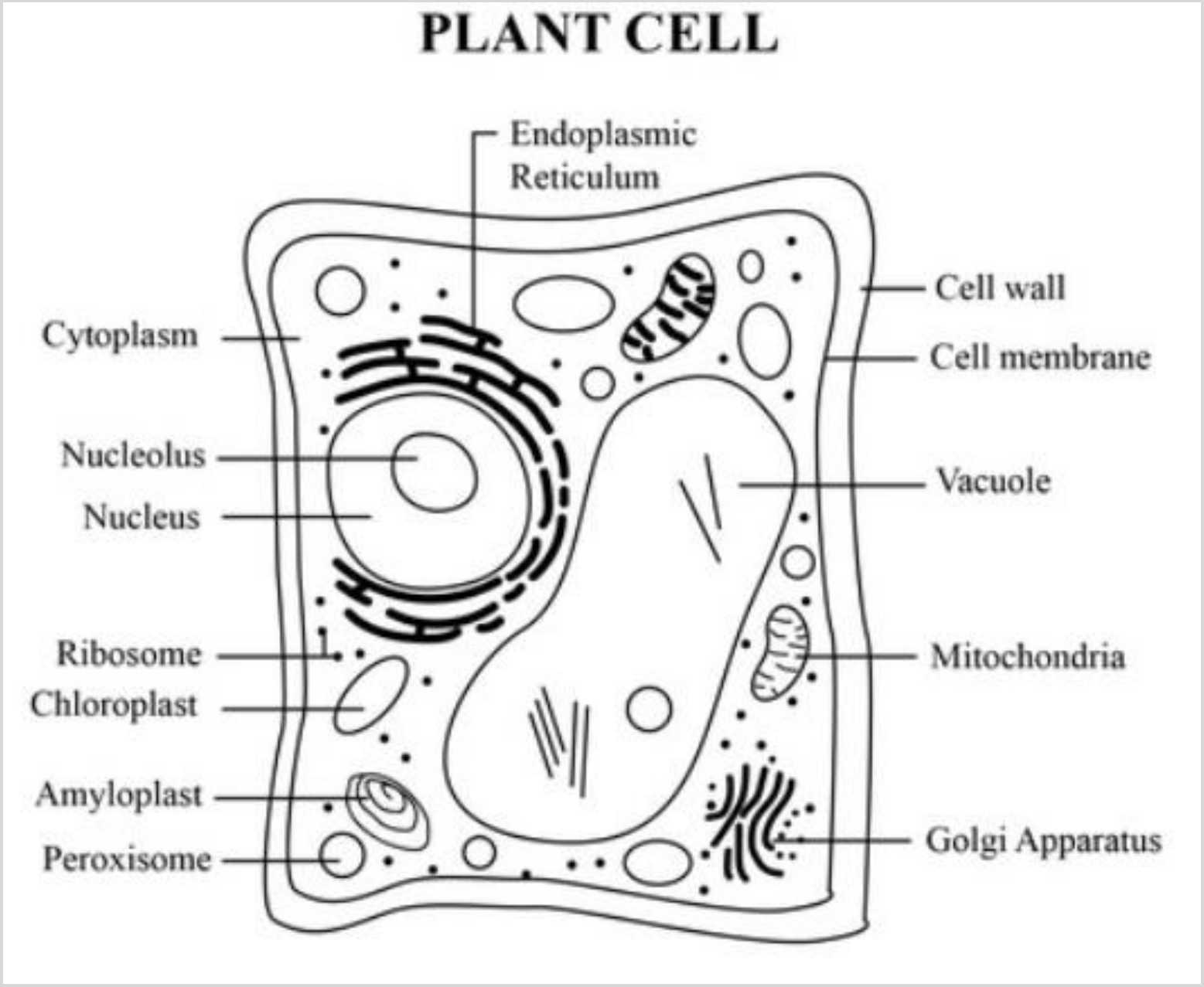
Delphinidin is darker on cloudy days, and particularly if cloudy days during bud development

Delphinidin , in iris flowers is darker when flower first opens

Not affected by different soils .

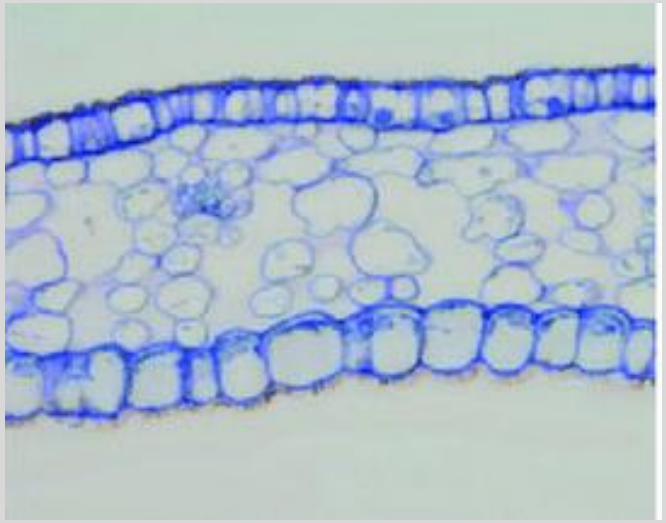
A family of chemicals . Not a single form






Anthocyanins are present as dissolved pigment located only inside plant vacuole

Located only in upper and lower epidermal layers of flower petals



Carlos Ayentos  UKN SDB

**Broken Dreams**  TB  (Keppel 1998)

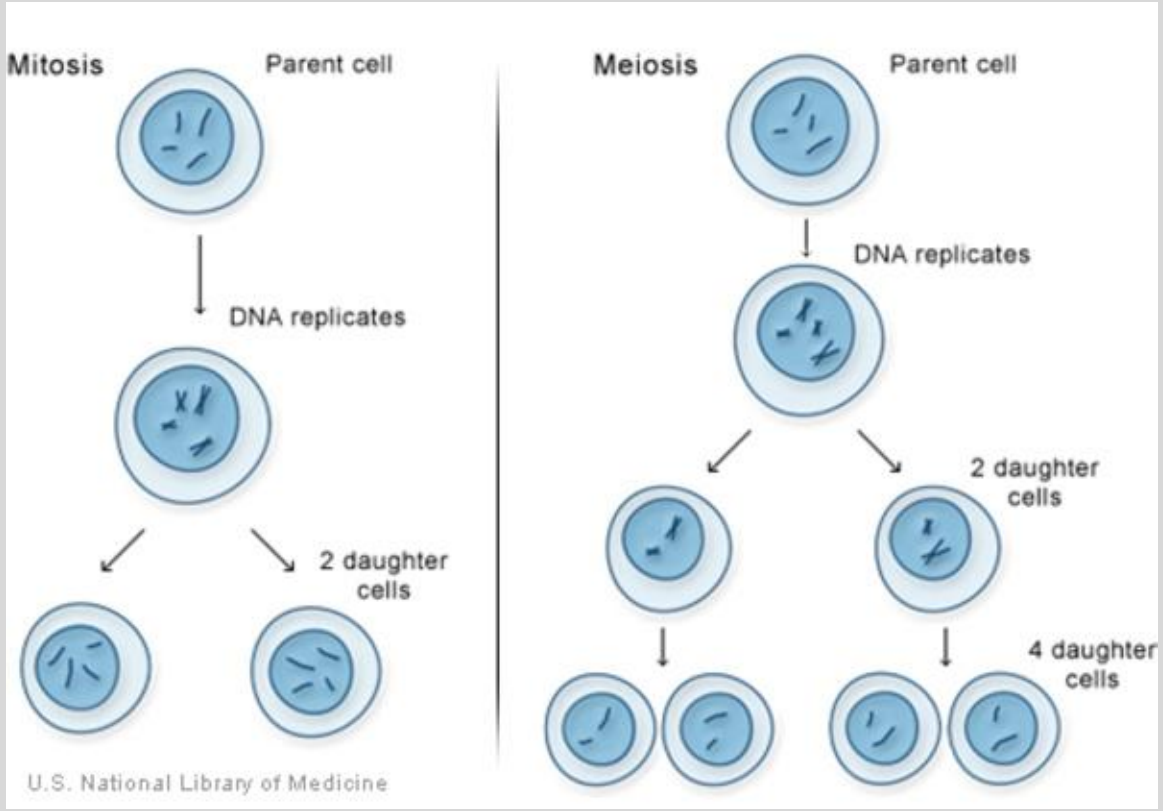

**Corsage** TB (Watkins 1955)

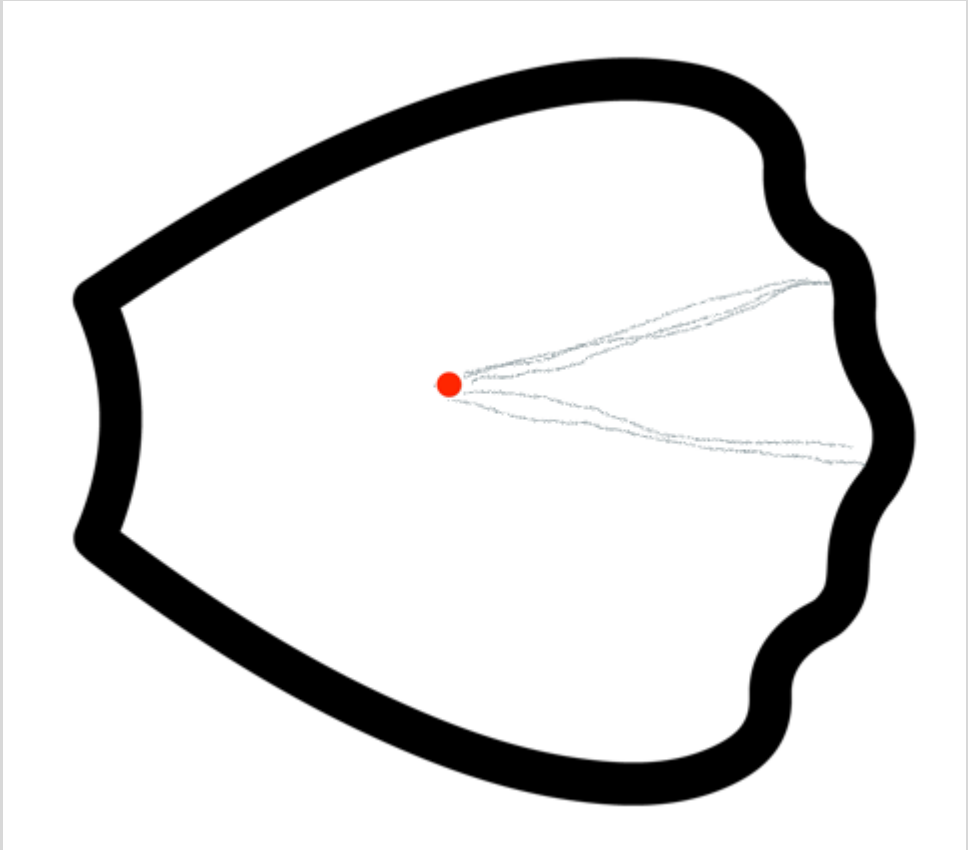
**Joseph's Coat** (Katkamier 1930)

**Cajun Rhythm** TB (Schreiners 1998)

**Chimera** results from a point mutation

# Cell division



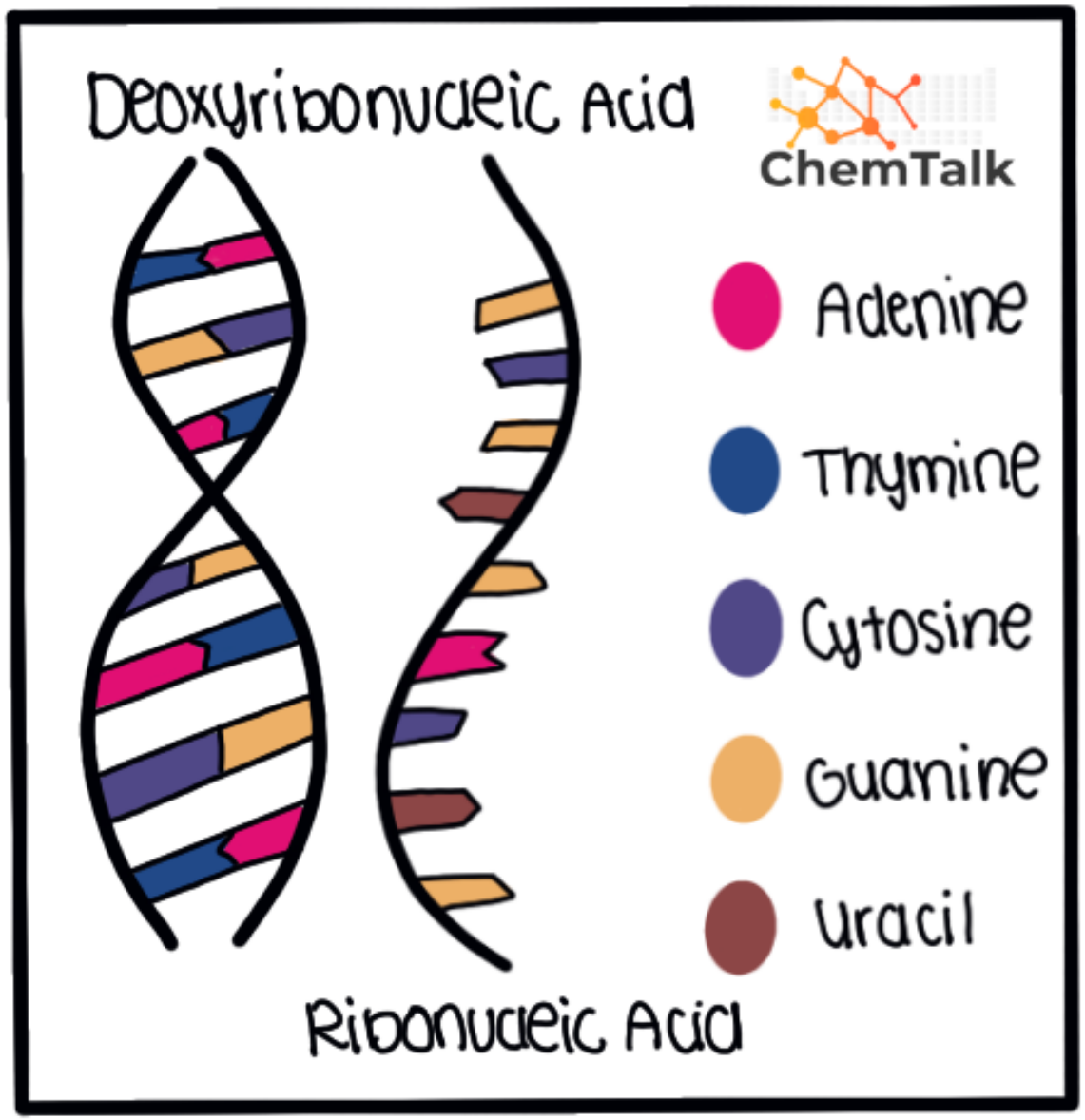



- Chimeras are developmental errors
- Errors in gene replication are about 1 in 600.000
- Chimeras are one off point mutations
- Chimeras are not repeatable
- Chimeras not passed on through increases

  Chimeras are not part of plants genetics, So cannot be passed on through breeding
  - Are in just one gene, removal of that gene function
- On rare occasions can be in somatic tissue and produce a mutation passed on through increases

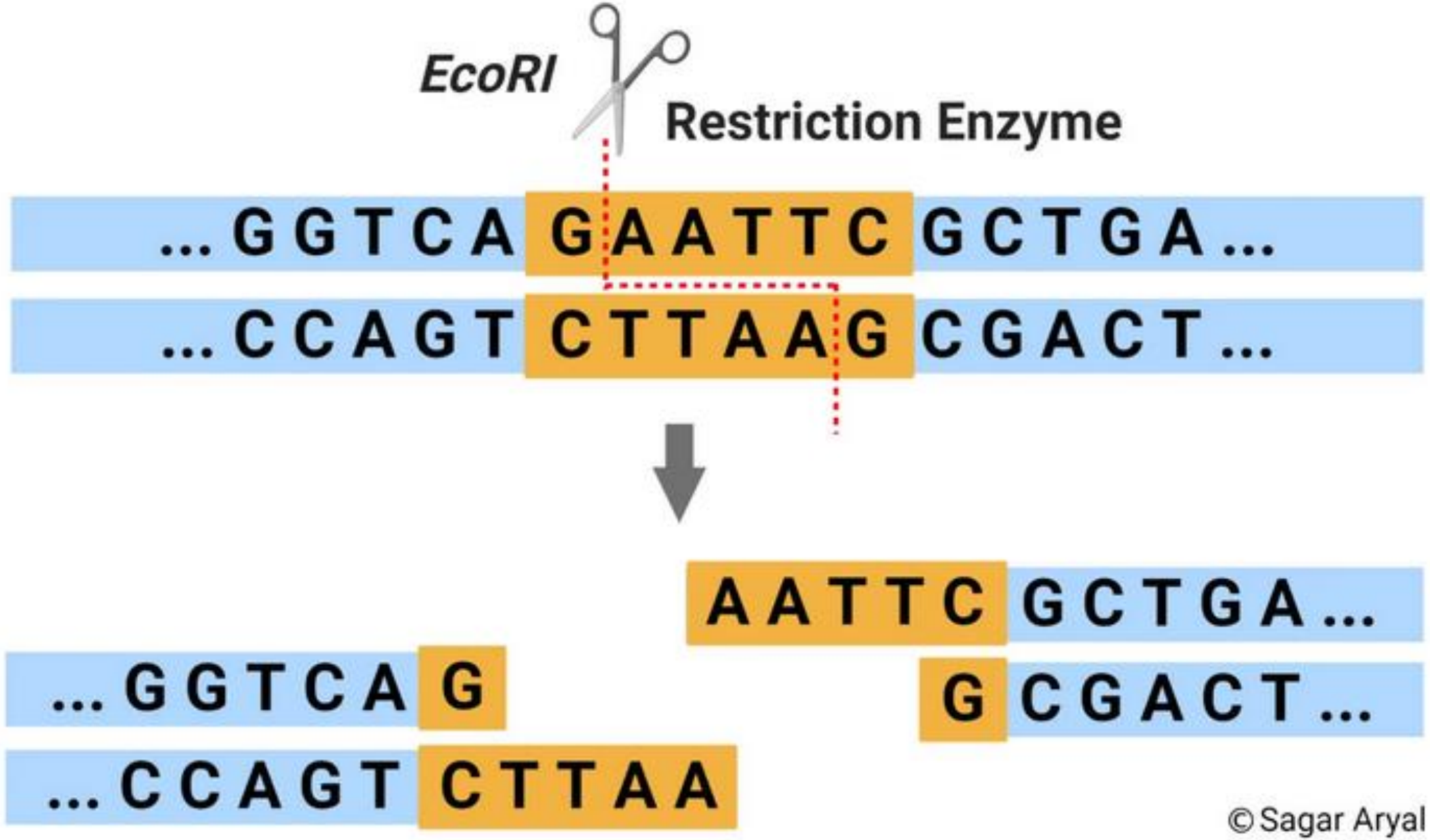
# Transposon (aka 'jumping gene')

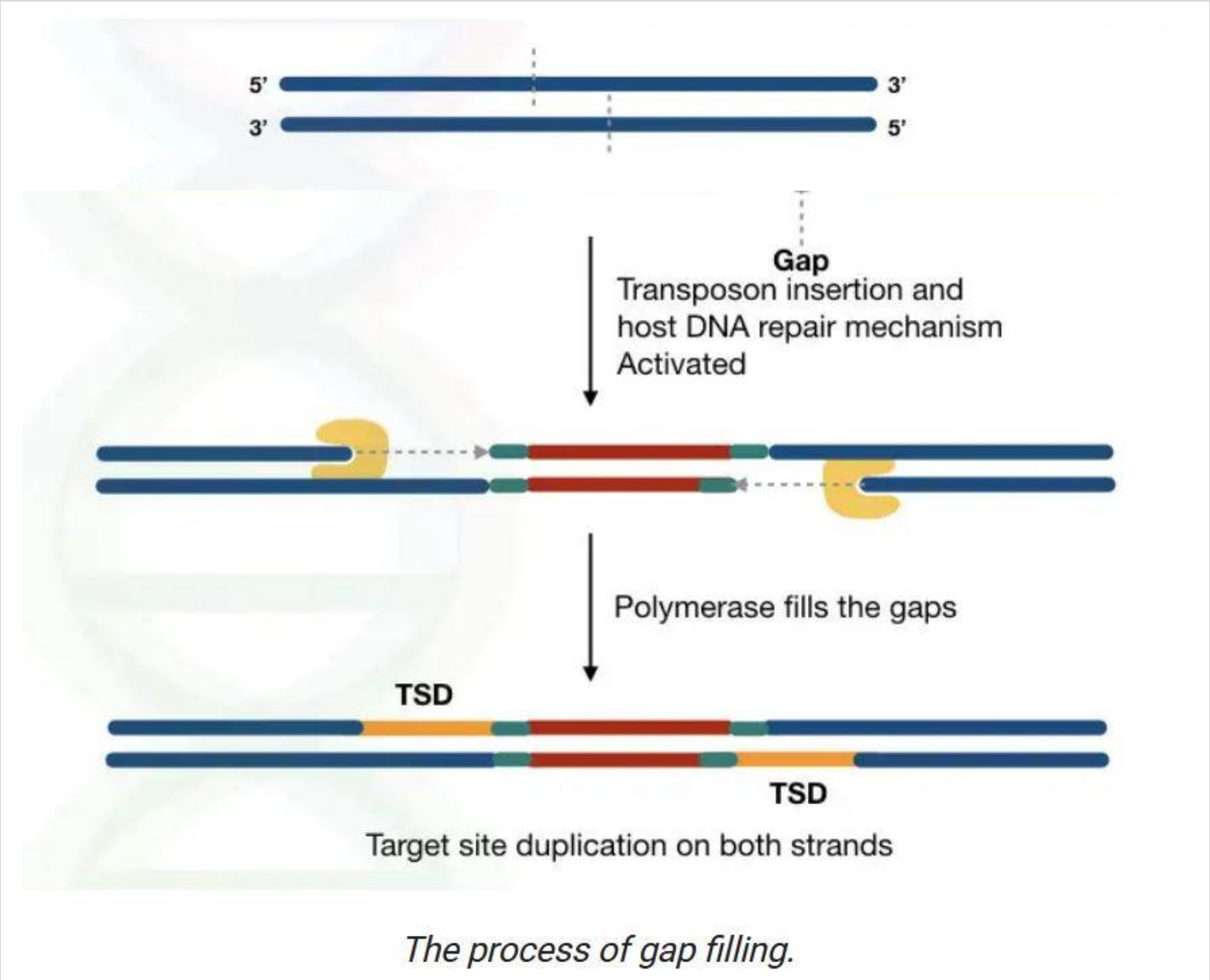
- The random variation in broken colour iris is attributed to transposon genes
- First discovered in corn by Barbra Mclintock. In 1940's
- Took a long time to be accepted by geneticists
- Involves two separate genes
- 1) 'Transposase ' which is a restriction enzyme which separates a DNA strand at a specific site
- 2) Target site ( both for place inserted and for insertion element)
- Gene for producing pigment is thus turned off and on
- Results in the multi coloured segments seen on many varieties of corn, seen primarily on decorative corn
- These two genes can be on separate chromosomes
- In iris it is a Type II Transposon, not a retro-transposon




| | Pairs |
|---|---|
| A | A-T |
| T | |
| C | C-G |
| G | |

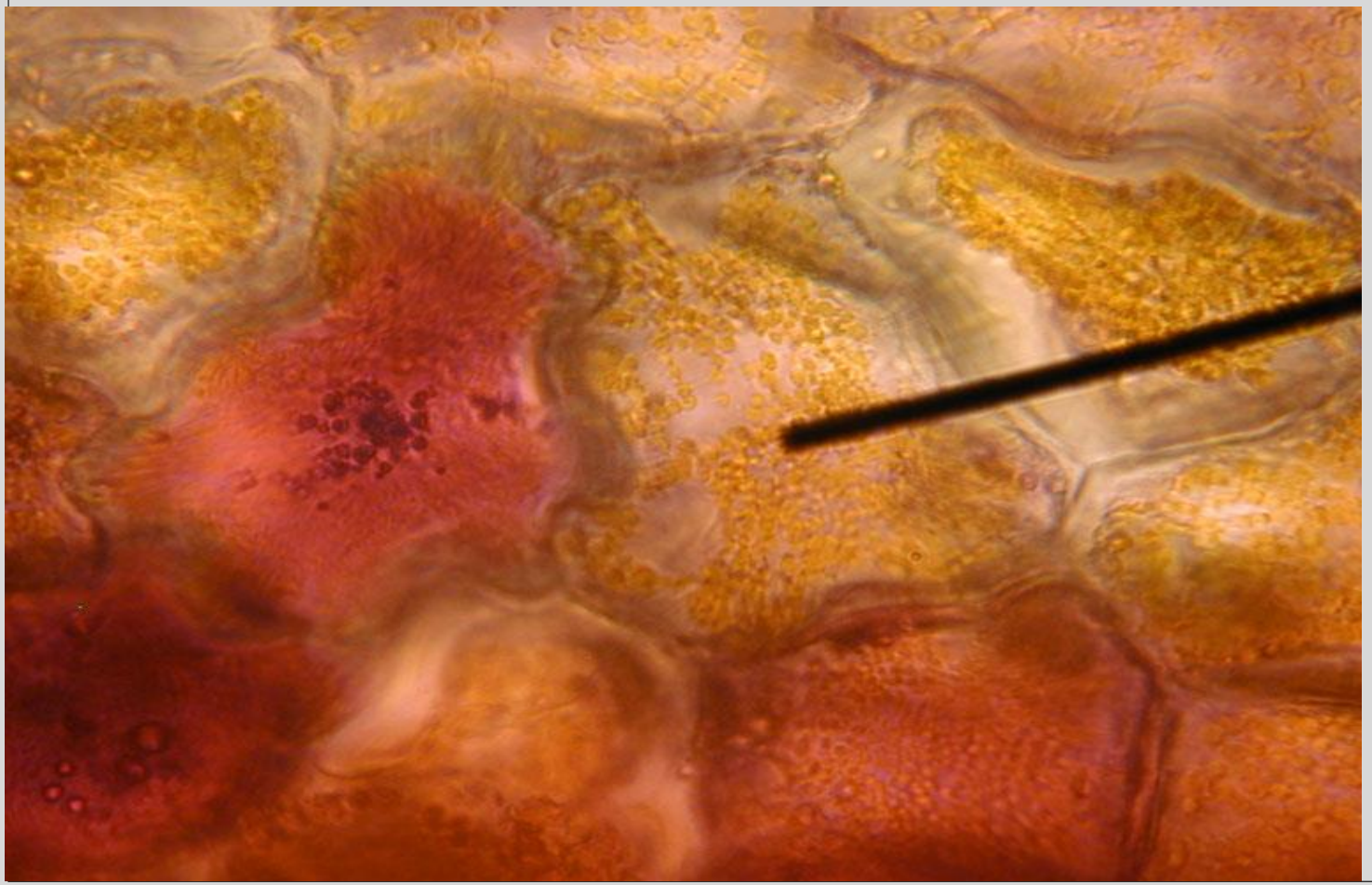
**5'CATATG**GAGTTTTTCAAAAAAACCGCACTGGCCGCACTGGT
TATGGGTTTTAGCGGTGCAGCACTGGCGTTTCCGACCATTCCG
CTGAGCCGCCTGTTTGATAACGCGATGCTGCGCGCGCATCGCC
TGCATCAGCTGGCGTTTGATACCTATCAGGAATTTGAAGAAGC
GTATATTCCGAAAGAACAGAAATATAGCTTTCTGCAGAACCCG
CAGACCAGCCTGTGCTTTAGCGAAAGCATTCCGACCCCGAGC
AACCGCGAAGAAACCCAGCAGAAAAGCAACCTGGAACTGCT
GCGCATTAGCCTGCTGCTGATTCAGAGCTGGCTGGAACCGGT
GCAGTTTCTGCGCAGCGTGTTTGCGAACAGCCTGGTGTATGG
CGCGAGCGATAGCAACGTGTATGATCTGCTGAAAGATCTGGA
AGAAGGCATTCAGACCCTGATGGGCCGCCTGGAAGATGGCAG
CCCGCGCACCGGCCAGATTTTTAAACAGACCTATAGCAAATTT
GATACCAACAGCCATAACGATGATGCGCTGCTGAAAAACTATG
GCCTGCTGTATTGCTTTCGCAAAGATATGGATAAAGTGGAAAC
CTTTCTGCGCATTGTGCAGTGCCGCAGCGTGGAAGGCAGCTG
CGGTTTTTAA**GGATCC 3'**


EcoRI
Restriction Enzyme
...GGTCAGAATTCGCTGA...
...CCAGTCTTAAGCGACT...
AATTCGCTGA...
GCGACT...
...GGTCAG
...CCAGTCTTAA
© Sagar Aryal




*The process of gap filling.*

# Anthocyanin Vascular Inclusions



Anthocyanin is normally in plant vacuole in a dissolved solution state.

But can form solid clumps through a binding of ramose sugar molecules.

With these clumps we can get very dark blue and black instead of just a bluish-purple

This is a dominant gene

Called **A**nthocyanin **E**nhancement **'Ae'**

03-547 Seedling

Shadow Of Night TB (Tasco 2006)

## Broken Colour gene

The transposon producing broken colour is in the anthocyanin gene

I'm calling this the Ae ( anthocyanin enhancement) gene Ae with transposon , **AeT**

Capital letters as it is a dominant gene. That is a gene that does something. Needs to be something the **AeT** gene can show on

**Background**

Can be white or any of the carotenoid pigments , all the different yellow, orange or pink
Or a light blue or violet

**Momma's Angel** TB (Spoon 2009)
A glaciata

**22-083-1** TB seedling Chapman

**Robin Goodfellow**
(Mahan, 1994)
rra  Recessive white

**Scrambled**
(Black, 2014_

**21-897-4** TB seedling Chapman
rra Recessive white?

**21-792-1** TB seedling Chapman

Seedling  Gary Schegel
((Apparent Secret x Puccini)

Gary Schegel seedling
(seedling  x Die Laughing)

**Codicil** ( Innerst, R. 1985)

**Broken Pattern** (Black 2004)

**Blueberry Bliss** (Schreiner 2004).


**_Brambleberry Blast** (Ava Toth 2021)

**Afternoon Delight** TB (Ernst 1985)

**13-418-4** TB seedling Chapman

**11-238-1** TB seedling Chapman

**21-898-1** TB seedling Chapman

# Genetics

**Robin Goodfellow**
(Mahan, 1994)

No anthocyanin

**Scrambled**
(Black, 2014_

BC (Broken colour)

**Think Spring**
(S Markham, 2003).

Regular
Anthocyanin


**Talking Smack**
(Miller 2021)

Anthocyanin + Ae

Many of the Broken Colour cultivars are on a classic plicata background. The white in centre of falls and standards are a nice clean background to show **AeT** gene. Plicata is a recessive.

**Creative Stitchery** (Schreiners , 1984)

**Batik** BB (Ensminger, 1986

**Batik**

# Variations in Frequency and duration of Transposons

**Don't Doubt Dalton** TB
( Burseen 2015)


**Meant To Doit** TB
(Black 2016)


**Break The Barrier** TB
( M. Sutton 2024)



**Don’t Doubt Dalton** TB
( Burseen 2015)


**Orangutan Orange** TB (Kasperek 2009)



**Jackal Crackle** TB (Kasperk 2002)

**Millenium Falcon** TB (Kasperk 2000)

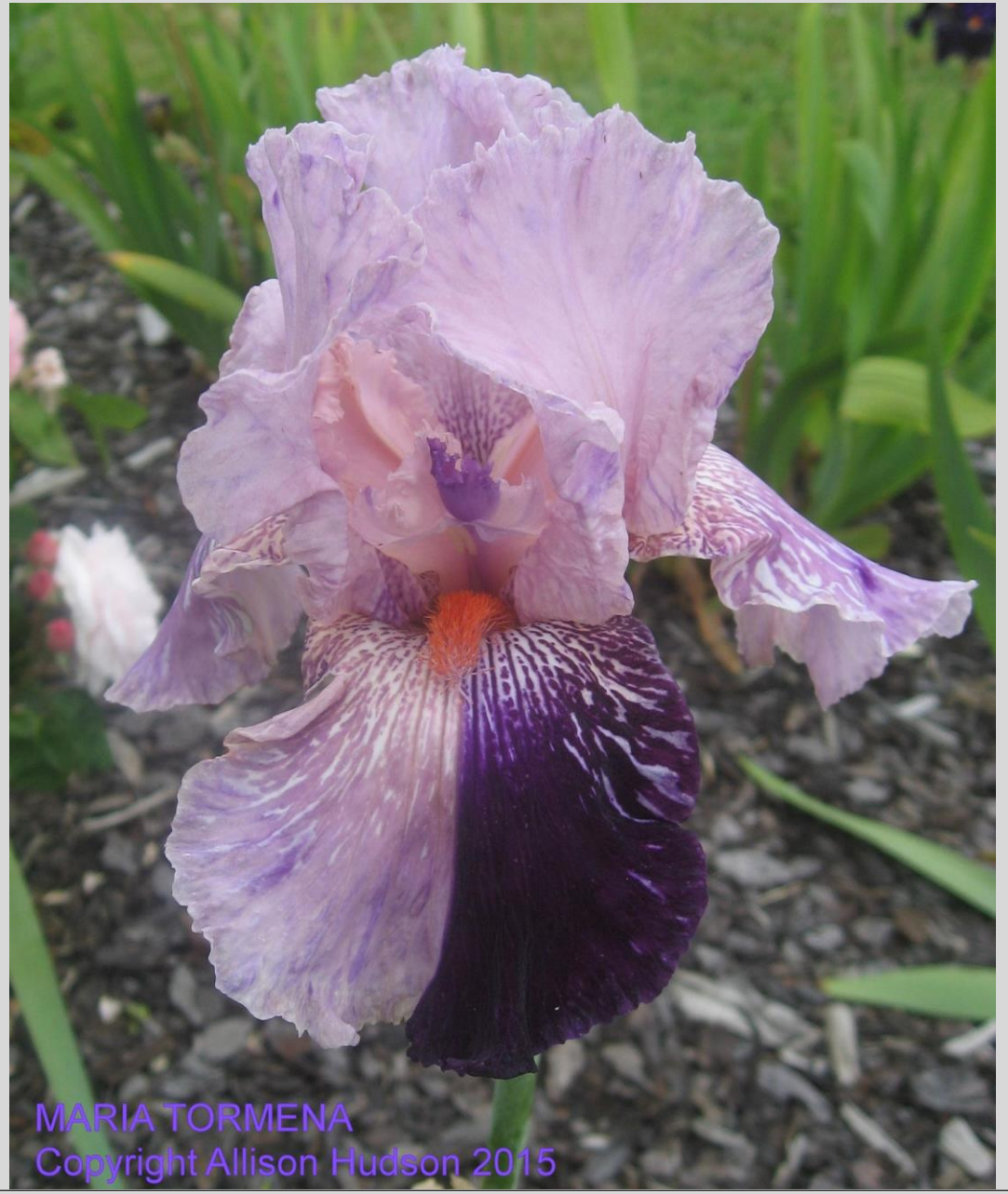

**Coyote Ugly** TB (Kathie Kasperek 2007)

**Toucan Tango** TB (Kasperek 2000)


**Wizard Of Odds** TB (Black 2009)

**Minnesota Mixed Up Kid** BB
(Unknown, in circulation 1970's

**Maria Tormena** TB (Ensminger 1987)



**Raspberry Silk** BB ( Spoon 2000)


**Gnu Blues** TB (Kasperek 1994)


**Peach Jam** TB (Ensminger 1989)


**King Tush** TB (Kaserek 1997)

**Gnu** TB (Kasperek 1994)



**Gnu Again** TB
(Kasperek 1994)



**Gnu Again** TB (Kasperek 1994)


# Hotdog And Mustard

TB (K. Kasperek 1995)

13-312-1 Seedling Chapman

**Batik** BB (Ensminger 1986)


**Alpha Gnu** IB (Kasperek 1999)

# Out of the Blue

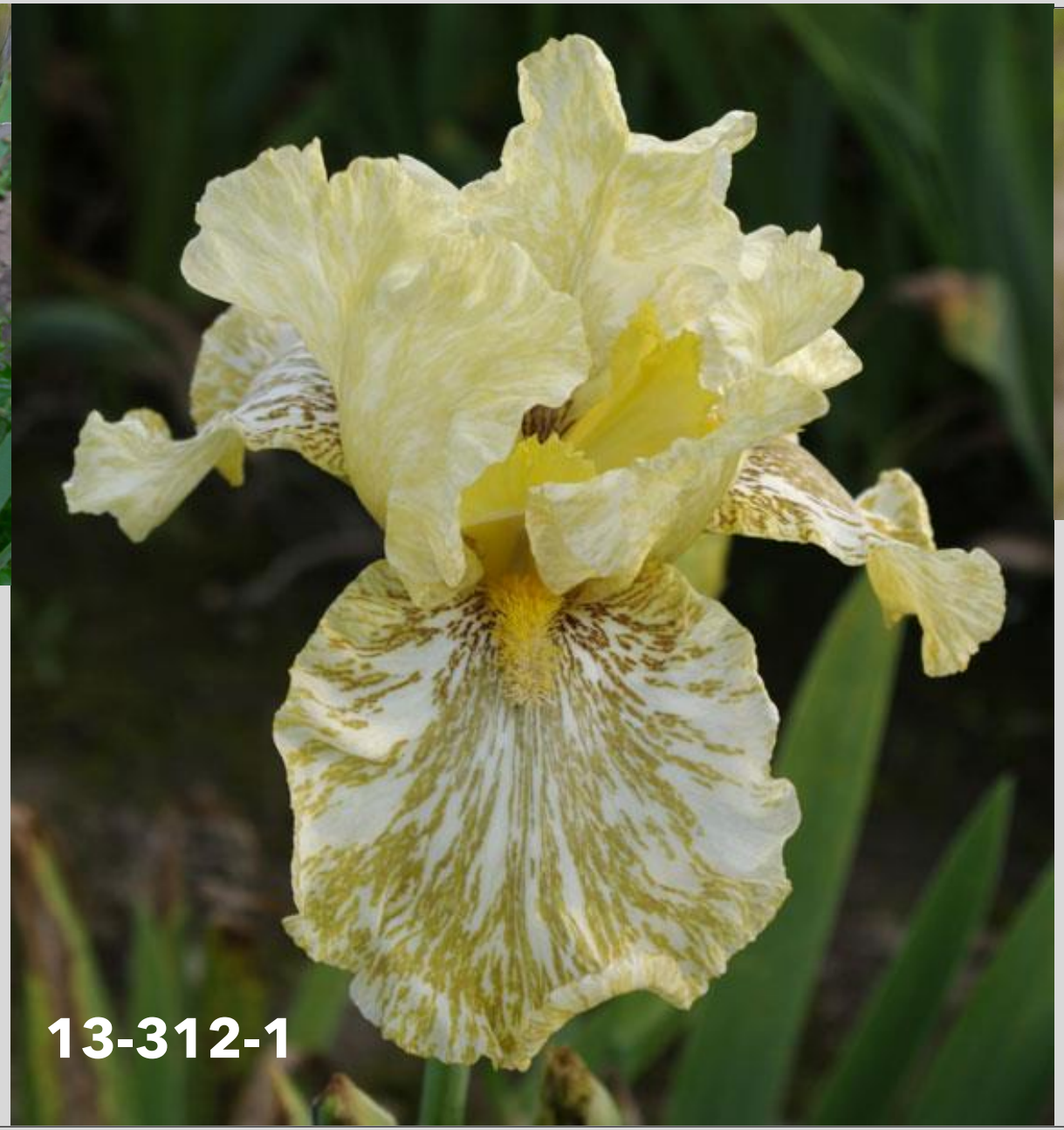
**Make Up Your Mind** TB (Black 2024)

**21-464-2** TB seedling  Chapman


**C94-1** TB (seedling Bailey Schiller)

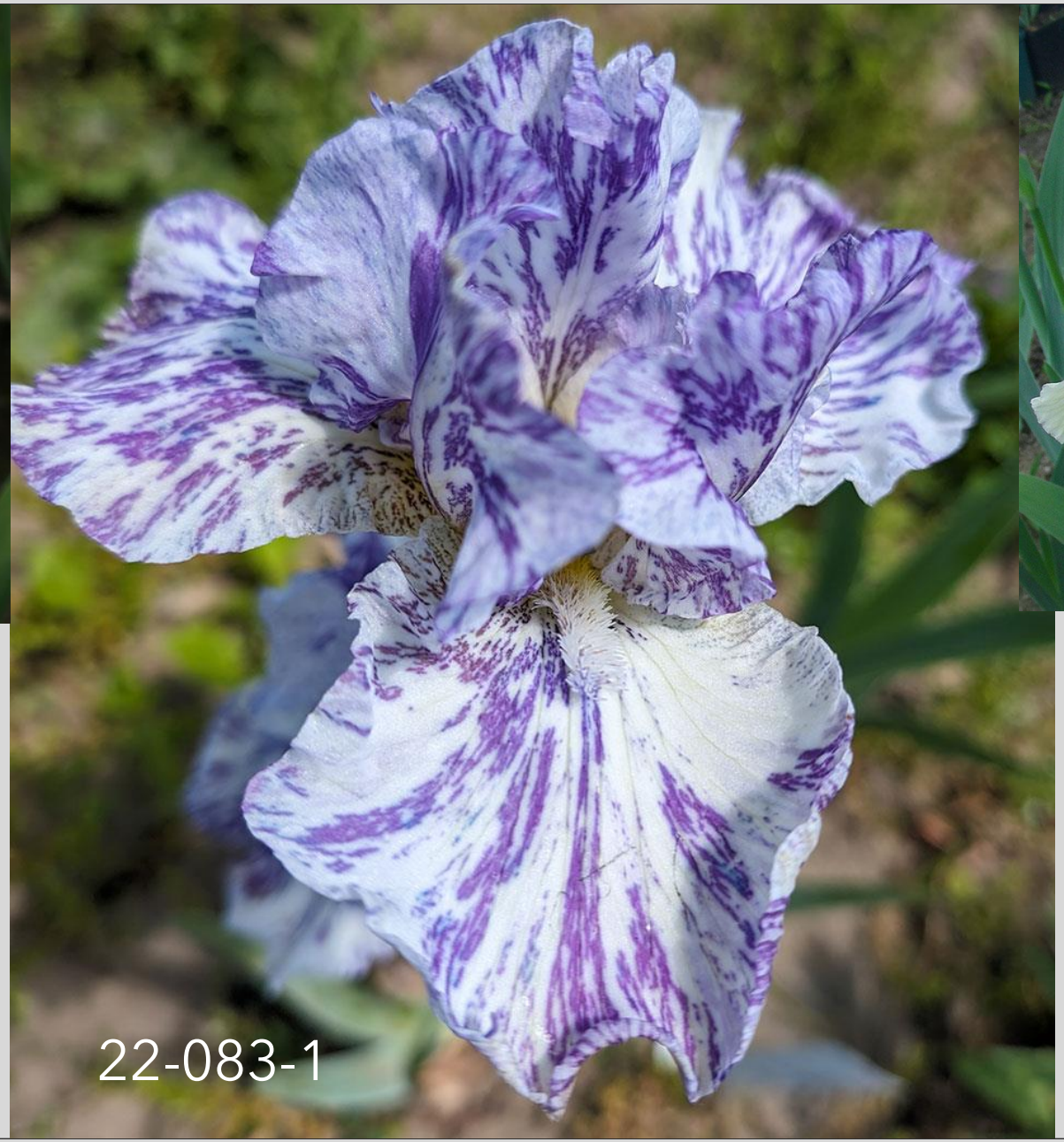

**Creative Confusion** TB (M Sutton 2020)

**08-805-2**



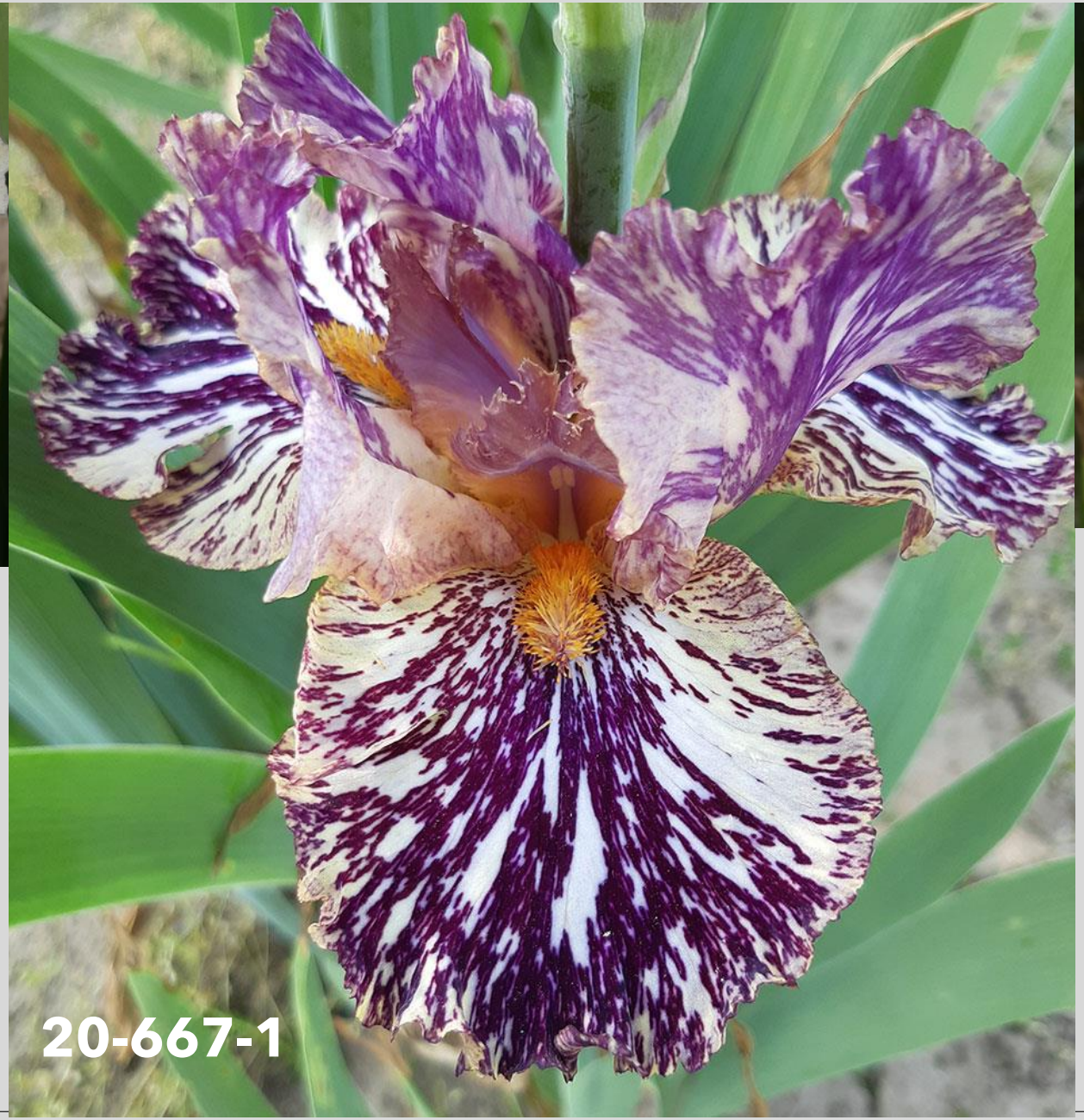

**Peggy Anne** TB
( G Sutton 2007)

**13-312-1**




**Momma's Angel** TB
(Spoon 2009)

13-365-2



20-667-1

13-312-1

21-919-1

13-616-2

**06-050-1**

Ragtime Singer

**Balderdash** TB (Keppel 2002)

# Ragtime Singer

Ragtime Singer

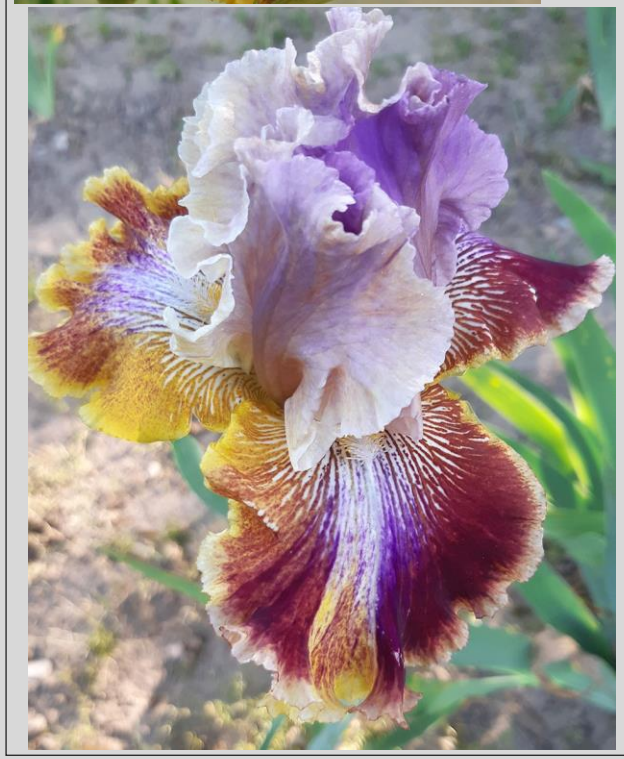

Die Laughing

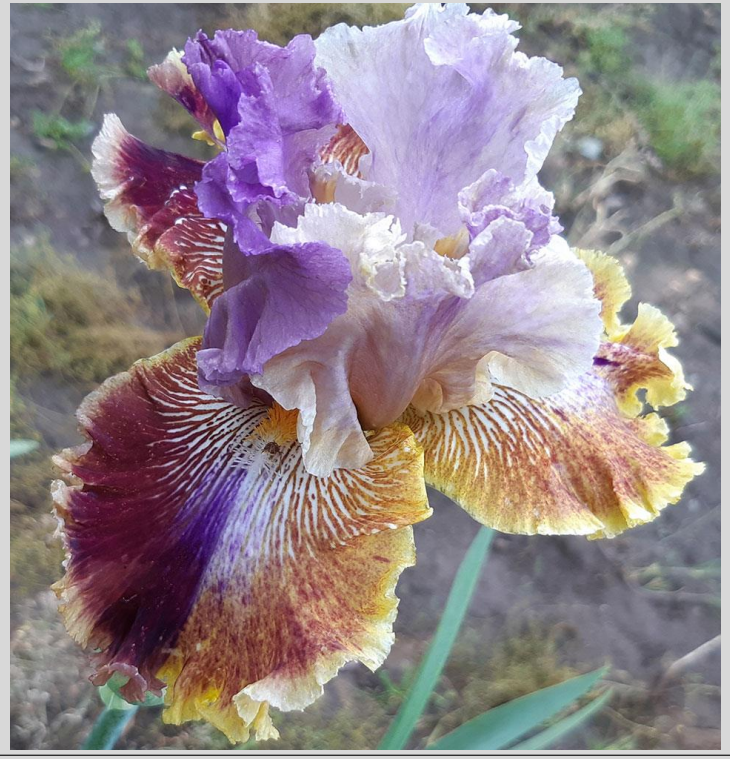
# 21-969

Ragtime Singer  X Big Break

# 20-490-2

13-413-4 X Die Laughing

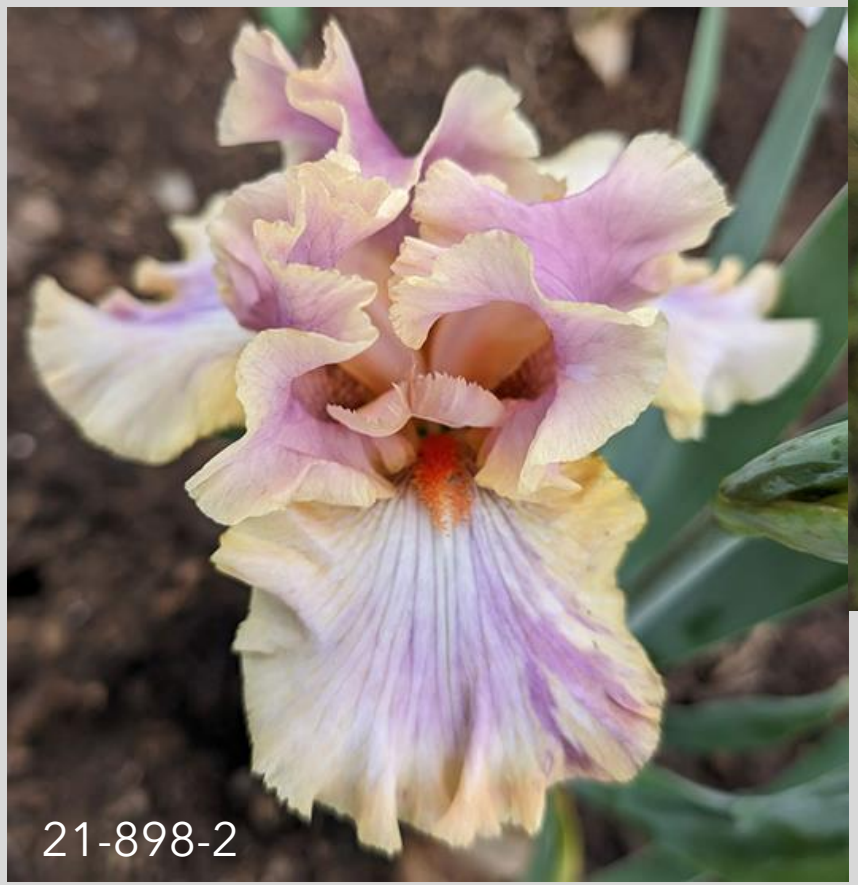




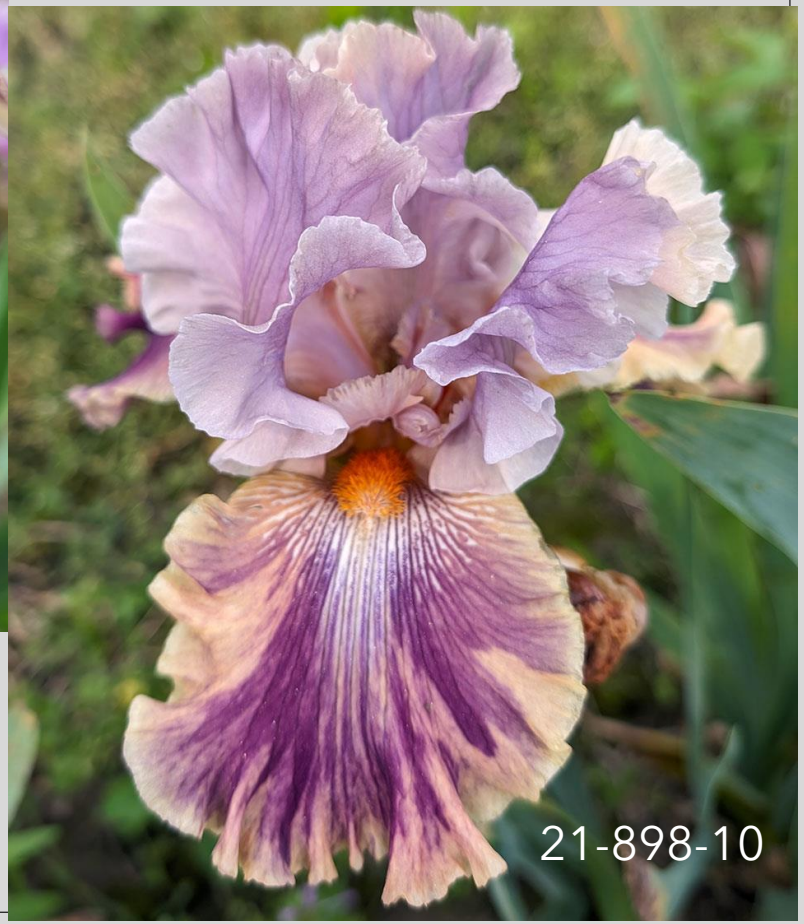
**11-238-1**



**Die Laughing**
TB (Black 2014)


21-898-2


21-898-4


21-898-10

# Plicata versus Non-Plicata

**Plicata**

More consistent expression

More contrast in colours

Darker colours

**Non-Plicata**

Higher frequency of BC in seedlings

Higher number of colours in a flower

Carotenoid backgrounds

Better growers in colder climates

Broken colour can be on many backgrounds, needs to be a light background to be dramatic

Broken colour gene as currently is in **Ae** gene, not in a plicata gene, so can be in many variations

The broken colour can be in a carotenoid pigment, but not currently identified or used

Various other factors can produce a n iris with multiple colours in a random fashion

Chimera
Round up
Virus
Identity issues of falls and standards
Random factors


The End