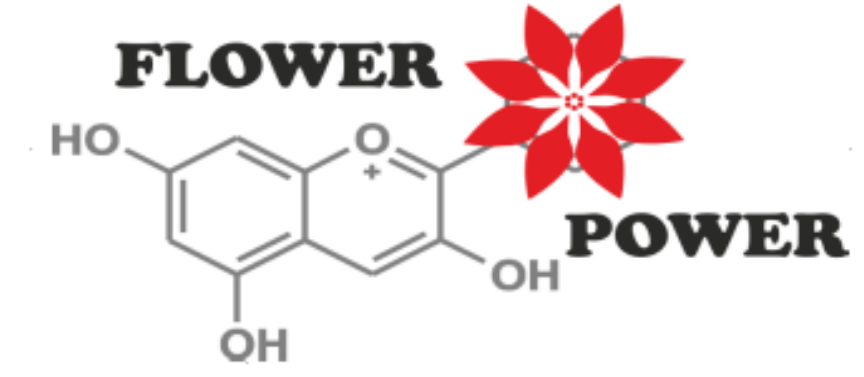


Understanding Color with the help of Computational Biology FlowerPower



MARIE CURIE ACTIONS

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One of the most important class of species that keeps the world in different colors are the flowers. Color is an important factor in nature not only for beauty but also for pollination. In this project we will focus on the analysis of the color-system in different flowers models in order to answer to different "enigmas" that appear in nature related to color .

Typical questions related to the flowers species in this project:

1. How Petunia gain so many colors naturally?
2. Why in Bidens the red color is very simetric oriented around the petals?
3. Red-White paradox in Poinsettia.

Figure 1. Exmaples of mRNA sequences

```
AATG TTAC ACGT TGCC CCGC CGTA
TAGC AAC TGAT TTCA TTAA GC CA .....
AATG TTAC ACGT TGCC CCGC CGTA
TAGC AAC TGAT TTCA TTAA GC CA .....
AATG TTAC ACGT TGCC CCGC CGTA
TAGC AAC TGAT TTCA TTAA GC CA .....
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In recent years, the next-generation sequencing technologies have been evolving rapidly, with the potential to accelerate biological and biomedical research dramatically. Therefore for different species the genomes and transcriptomes were analysed. In order to answer to the questions we also use genomic information.

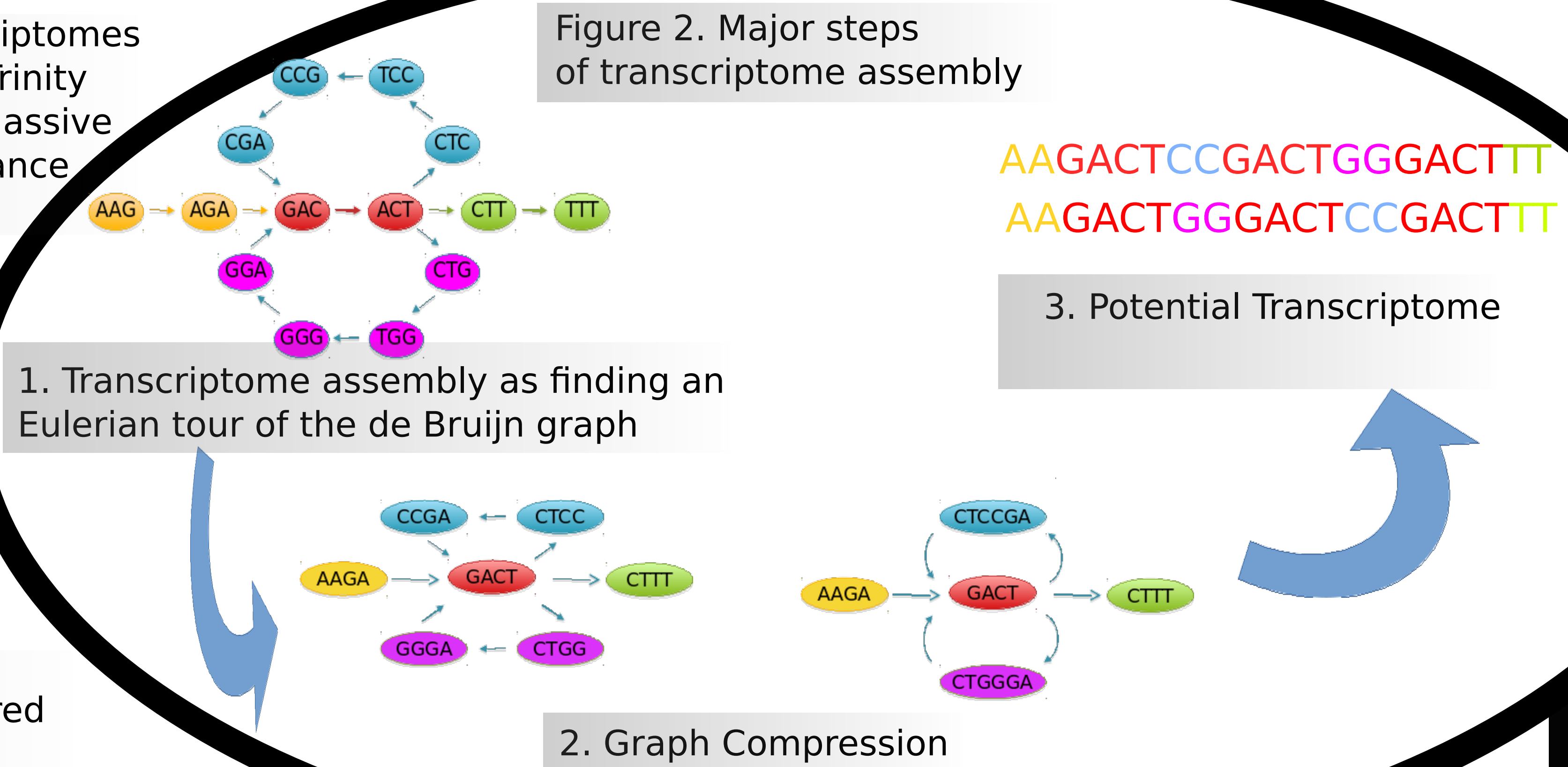
Plant genomes are very large (sometimes larger than the human genome). This make the sequencing of the DNA very expensive. Since in our project we have multiple flowers models to analyse we use RNA-sequencing.

For example as input in this project we have for Petunia RNA-sequencing from red, orange and blackberry. For Bidens from different position of the petals and for Poinsettia we have six pairs from red and white .

Massive RNA-sequencing enabled the basis to provide transcriptomes for various plant species. The assembly was performed with Trinity representing a de Bruijn graph based algorithm. Due to the massive amount of sequencing data we need to use our high performance grid at the computational cluster in the University of Vienna.



Figure 2. Major steps of transcriptome assembly



Petunia Natural Coloring

Anthocyanins are the most common class of floral pigments. They are responsible for most of the blue, purple, pink, and red colors we see in flowering plants. .

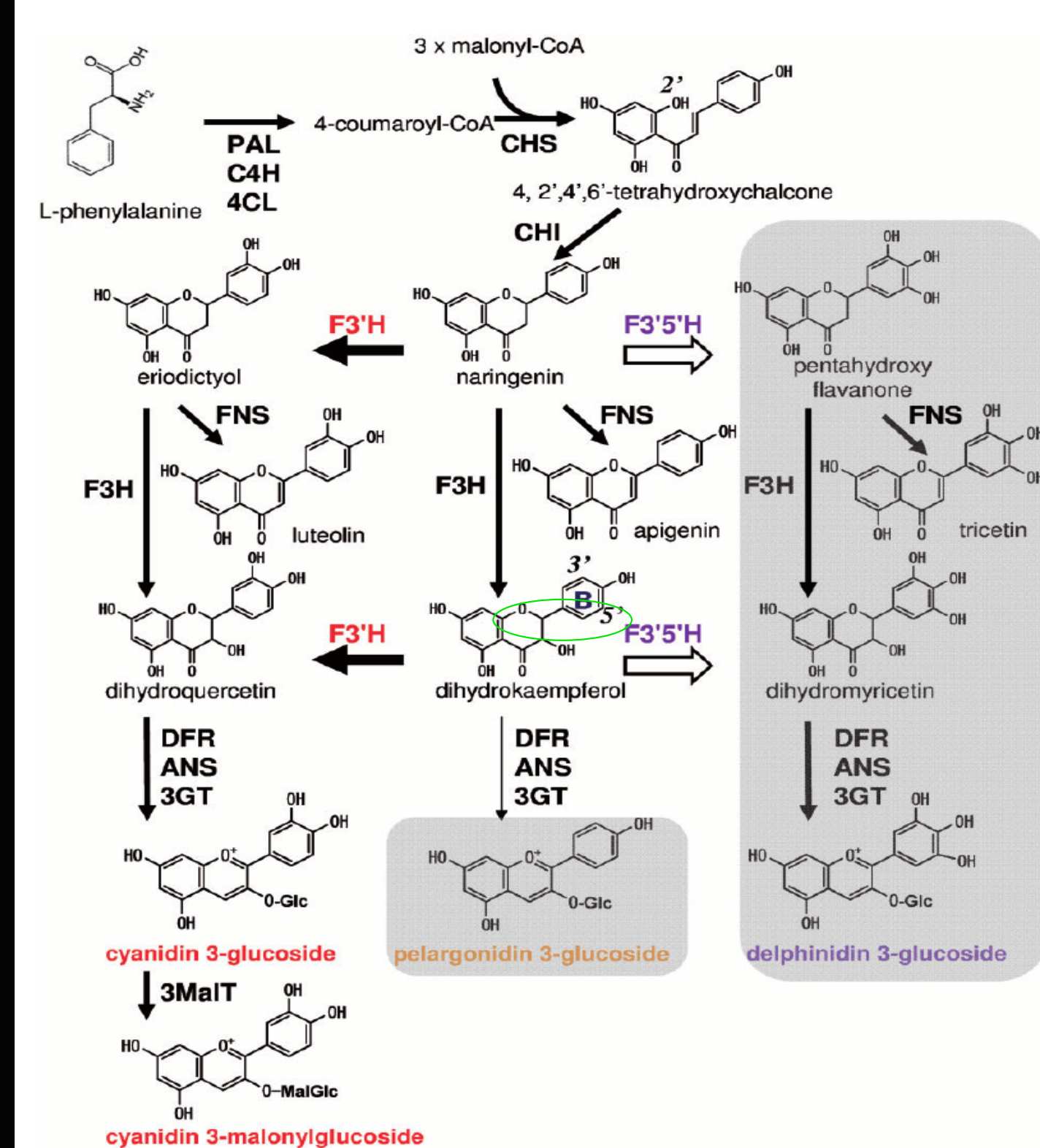


Figure 3. The pathway leading to the biosynthesis of the anthocyanidin. Abbreviations: CHS, chalcone synthase; F3H, flavanone 3-hydroxylase; F3'H, flavonoid 3'-hydroxylase; F3'5'H, flavonoid 3',5'-hydroxylase; DFR, dihydroflavonol 4-reductase; ANS, anthocyanidin synthase.

| | | |
|------|------|------|
| 359 | 917 | 844 |
| 286 | 777 | 878 |
| 562 | 564 | 415 |
| 293 | 454 | 461 |
| 425 | 330 | 1333 |
| 493 | 361 | 993 |
| 727 | 978 | 1024 |
| 657 | 772 | 1403 |
| 1032 | 946 | 682 |
| 632 | 1644 | 2099 |
| 560 | 1714 | 1357 |
| 188 | 479 | 371 |
| 219 | 324 | 265 |
| 97 | 480 | 215 |
| 121 | 1034 | 305 |
| 306 | 196 | 297 |
| 121 | 87 | 114 |
| 110 | 96 | 102 |
| 105 | 125 | 123 |
| 198 | 82 | 81 |
| 76 | 131 | 82 |
| 59 | 16 | 83 |
| 62 | 85 | 81 |
| 52 | 253 | 559 |
| 92 | 280 | 280 |
| 15 | 184 | 94 |
| 25 | 132 | 132 |
| 13 | 10 | 10 |
| 9 | 3 | 13 |
| 14 | 10 | 3 |
| 7 | 2 | 2 |
| 3 | 2 | 3 |
| 4 | 1 | 2 |
| 1 | 5 | 4 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 0 | 0 | 0 |



Figure 4. Expression of 46 genes from the anthocyanin pathway in 3 different color Petunias. The heatmap shows the higher number of expression of genes with black and lowest number with white. Some important genes are also marked with colors like in Figure 3.

Red-Yellow Mysteries

```
Bidens_Bottom MAESDEIQPLVCDNGTGMVKAGFAGDDAPRAVFPISVGRPRHTGVMVGMGOKDAYVGDEA
Bidens_Top MAESDEIQPLVCDNGTGMVKAGFAGDDAPRAVFPISVGRPRHTGVMVGMGOKDAYVGDEA
Bidens_Vein MAESDEIQPLVCDNGTGMVKAGFAGDDAPRAVFPISVGRPRHTGVMVGMGOKDAYVGDEA
*****
Bidens_Bottom OSKRGILTKYPIEHGIVSNWDDMEKIWHHTFYNELRVAPEEHPVLLTEAPLNPKANREK
Bidens_Top OSKRGILTKYPIEHGIVSNWDDMEKIWHHTFYNELRVAPEEHPVLLTEAPLNPKANREK
Bidens_Vein OSKRGILTKYPIEHGIVSNWDDMEKIWHHTFYNELRVAPEEHPVLLTEAPLNPKANREK
*****
Bidens_Bottom MTQIMFETFNAPAMYVAIQAVLSYASGRRTGIVLDSGGVSHVTVPIYEGYALPHAILRL
Bidens_Top MTQIMFETFNAPAMYVAIQAVLSYASGRRTGIVLDSGGVSHVTVPIYEGYALPHAILRL
Bidens_Vein MTQIMFETFNAPAMYVAIQAVLSYASGRRTGIVLDSGGVSHVTVPIYEGYALPHAILRL
*****
Bidens_Bottom DLAGRDITSLMKILTERGYSFTTAREIVRDMKEKLAYALDYEQELETSSRTSSIEK
Bidens_Top DLAGRDITSLMKILTERGYSFTTAREIVRDMKEKLAYALDYEQELETSSRTSSIEK
Bidens_Vein DLAGRDITSLMKILTERGYSFTTAREIVRDMKEKLAYALDYEQELETSSRTSSIEK
*****
Bidens_Bottom SYELPDGQVITIGAERFRCEPEVLFQPSMIGMEAGIHEHTTYSIMKCDVDIRKDYGNIV
Bidens_Top SYELPDGQVITIGAERFRCEPEVLFQPSMIGMEAGIHEHTTYSIMKCDVDIRKDYGNIV
Bidens_Vein SYELPDGQVITIGAERFRCEPEVLFQPSMIGMEAGIHEHTTYSIMKCDVDIRKDYGNIV
*****
Bidens_Bottom LSGGTMFPGIADRMKSKEITALSPSSMKIKVAPPERKYSVWIGGSILASLSTFQOMWIS
Bidens_Top LSGGTMFPGIADRMKSKEITALSPSSMKIKVAPPERKYSVWIGGSILASLSTFQOMWIS
Bidens_Vein LSGGTMFPGIADRMKSKEITALSPSSMKIKVAPPERKYSVWIGGSILASLSTFQOMWIS
*****
Bidens_Bottom KAEYDESGSIVHRKCF
Bidens_Top KAEYDESGSIVHRKCF
Bidens_Vein KAEYDESGSIVHRKCF
*****
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Yellow color in Bidens is not determined by Flavonols but by Anthoclor. For this we proceeded in searching for key-enzymes like chalcone-reductase actin and others to observe the differences in their sequences.

Outlook

Our aim in this project is to understand how petunia manage to "conquer" all new colors naturally, to determine the key enzyme behing the red-yellow enigma in Bidens and to solve the red-white paradox in Poinsettia.