A molecular mechanism for bright color variation in parrots

Luo Senyu

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About the team

Curriculum Vitae

Miguel Carneiro

I am currently a Principal Investigator and the group leader of the EVOLGEN group (Evolutionary Genetics and Genomics) at CIBIO/InBIO, University of Porto. EVOLGEN brings together researchers that are interested in evolutionary change and in the genetic determinants underlying the immense biological diversity in nature. More broadly, my ultimate goal is to map phenotypic variation to the gene level, and equipped with this information, I aim to shed light on the mutational mechanisms explaining both simple and complex trait variation and contribute to help answering questions of general interest in biology associated with

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RESEARCH ARTICLE

PIGMENTATION

A molecular mechanism for bright color variation in parrots

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MIGUEL CARNEIRO, CARL-JOHAN RUBIN, FEDERICA DI PALMA, FRANK W. ALBERT, JESSICA ALFÖLDI, ALVARO MARTINEZ BARRIO, GERLI PIELBERG, NIMA RAFATI, SHUMAILA SAYYAB, [...], AND LEIF ANDERSSON +30 authors Authors Info & Affiliations

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A mechanism for red coloration in vertebrates

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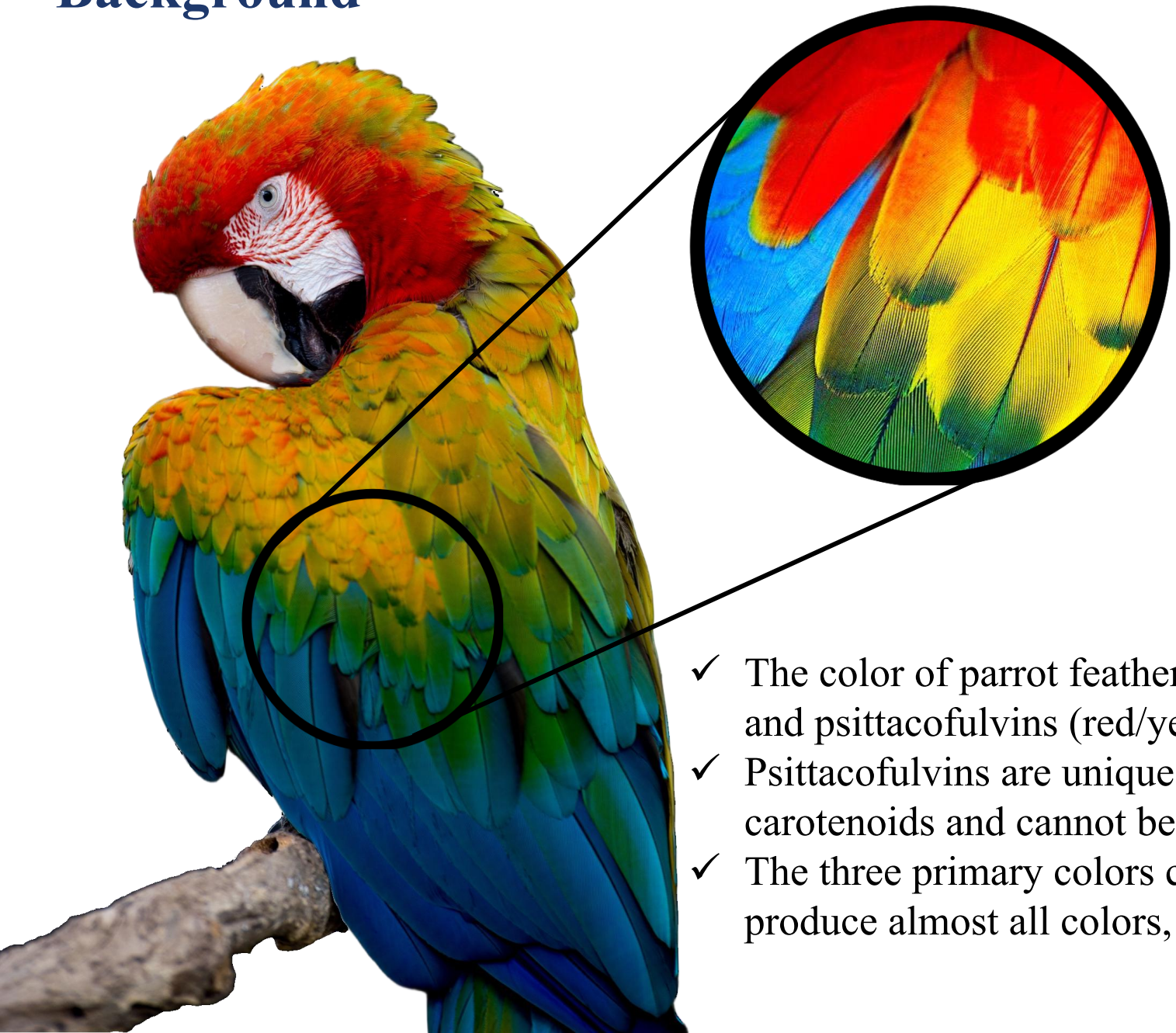
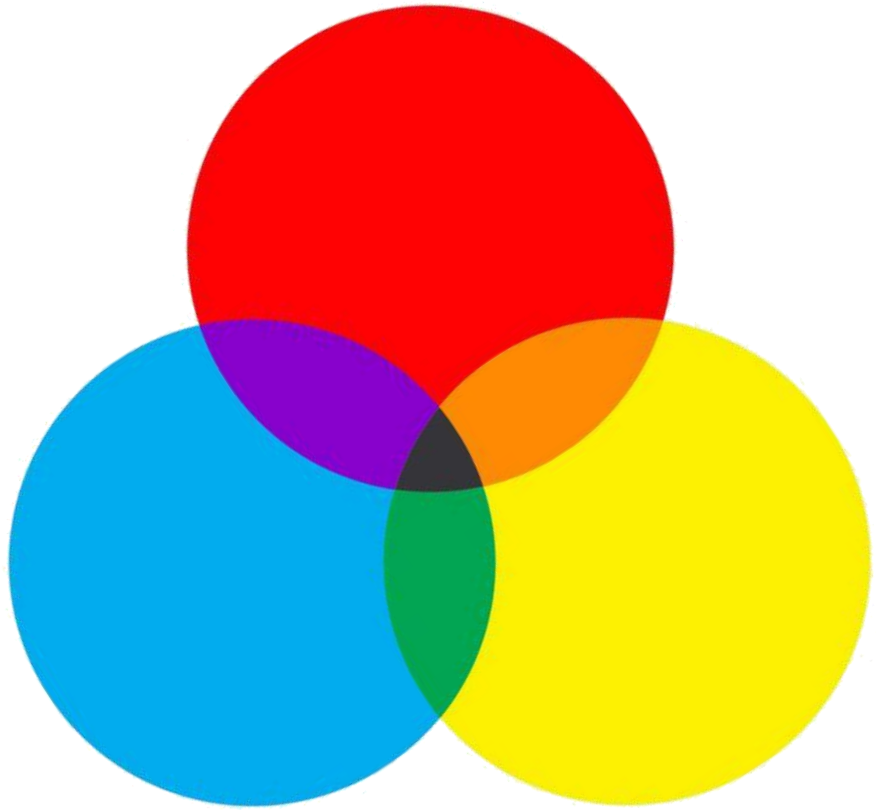
Affiliations & Notes Article Info

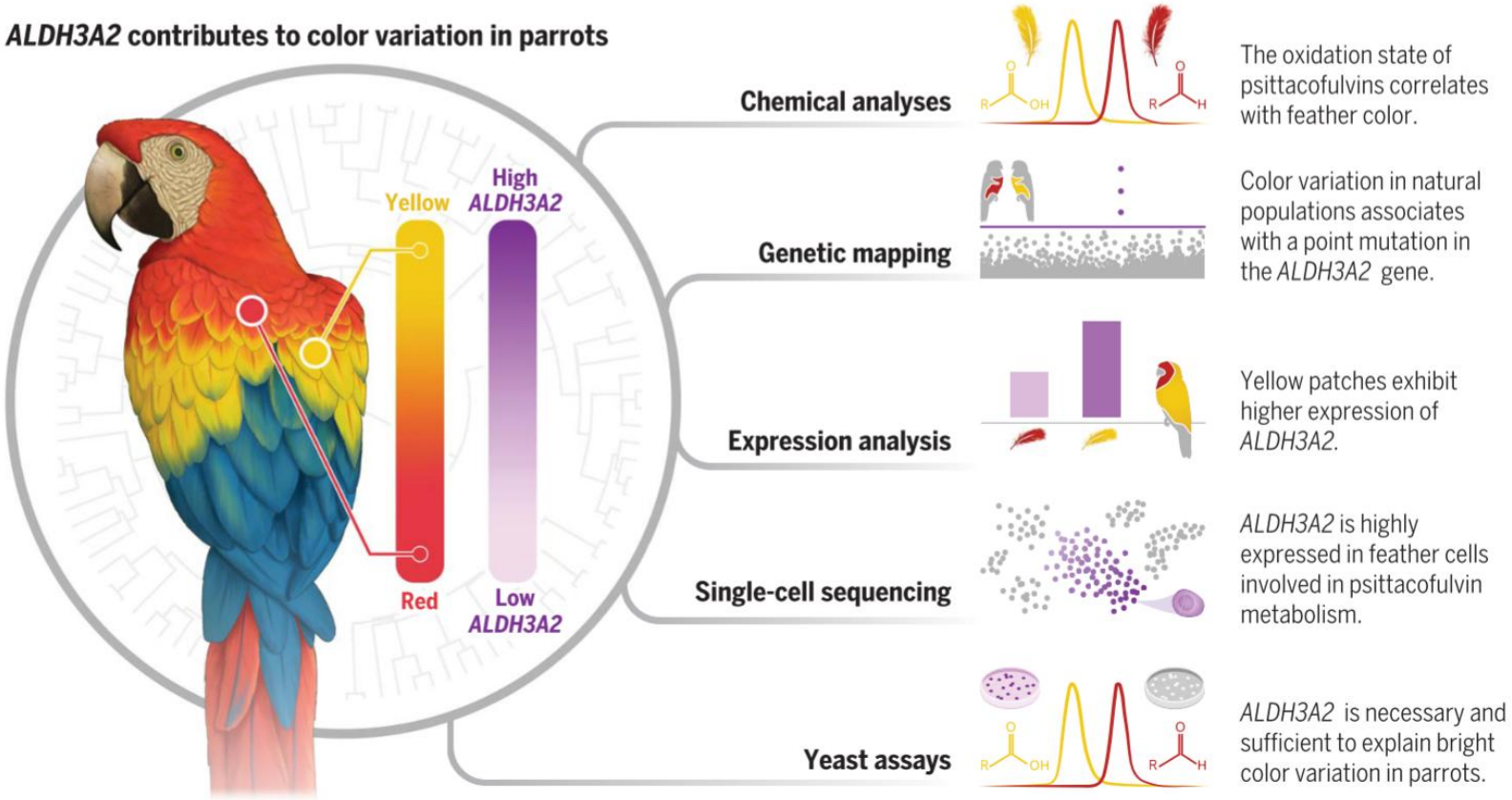
Background

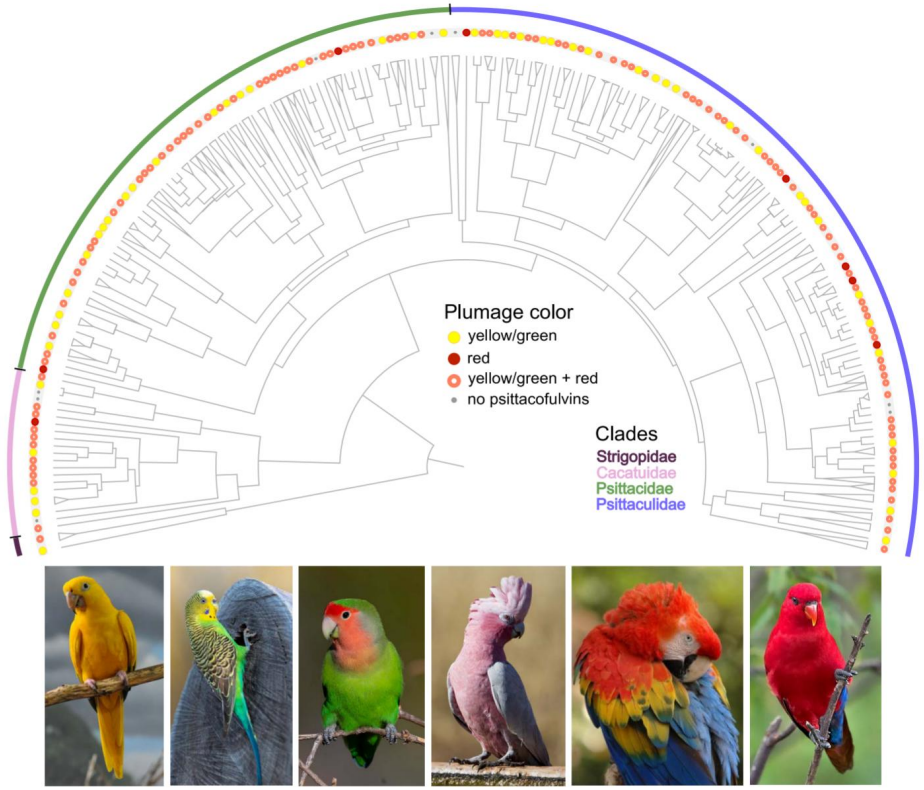




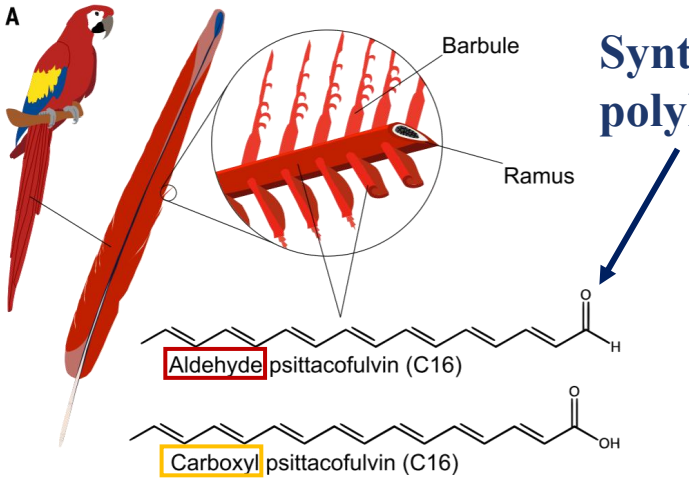
- ✓ The color of parrot feathers is determined by structural colors (blue) and psittacofulvins (red/yellow).
- ✓ Psittacofulvins are unique pigments found in parrots, differing from carotenoids and cannot be supplemented through diet.
- ✓ The three primary colors can be mixed in different proportions to produce almost all colors, which is why parrot feathers are so colorful.

Abstract

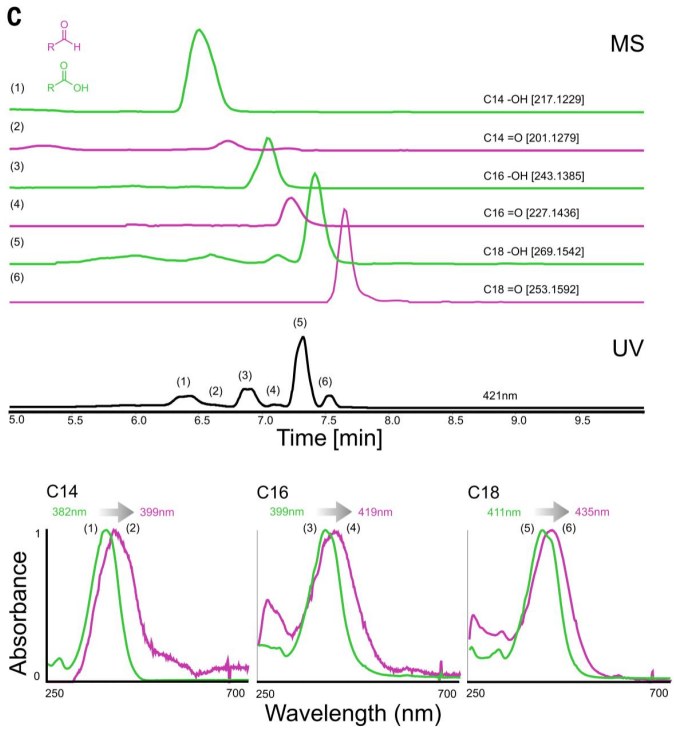

ALDH3A2 contributes to color variation in parrots
Yellow
High ALDH3A2
Red
Low ALDH3A2
Chemical analyses
Genetic mapping
Expression analysis
Single-cell sequencing
Yeast assays
The oxidation state of psittacofulvins correlates with feather color.
Color variation in natural populations associates with a point mutation in the ALDH3A2 gene.
Yellow patches exhibit higher expression of ALDH3A2.
ALDH3A2 is highly expressed in feather cells involved in psittacofulvin metabolism.
ALDH3A2 is necessary and sufficient to explain bright color variation in parrots.

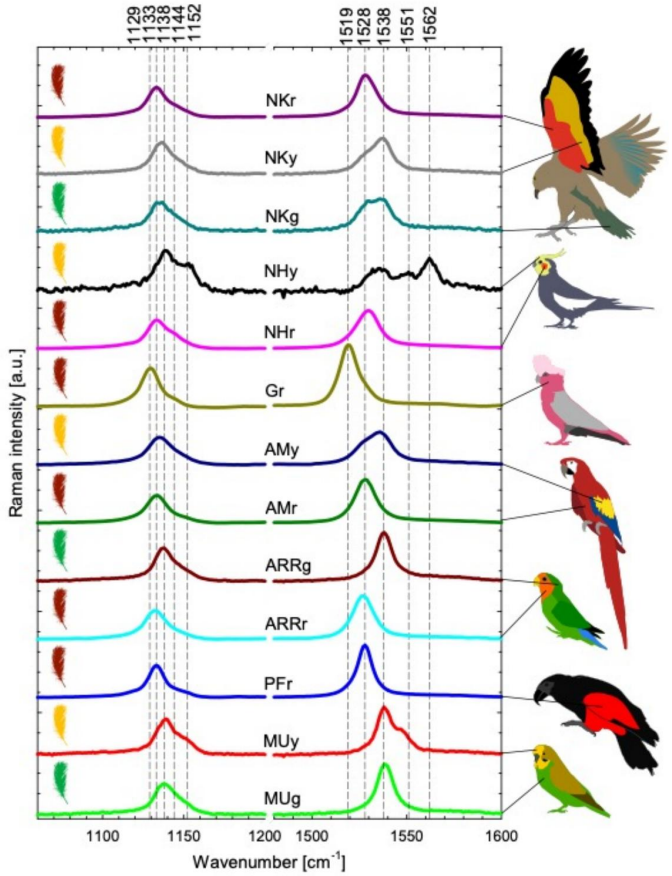

Plumage color
yellow/green
red
yellow/green + red
no psittacofulvins
Clades
Strigopidae
Cacatuidae
Psittacidae
Psittaculidae

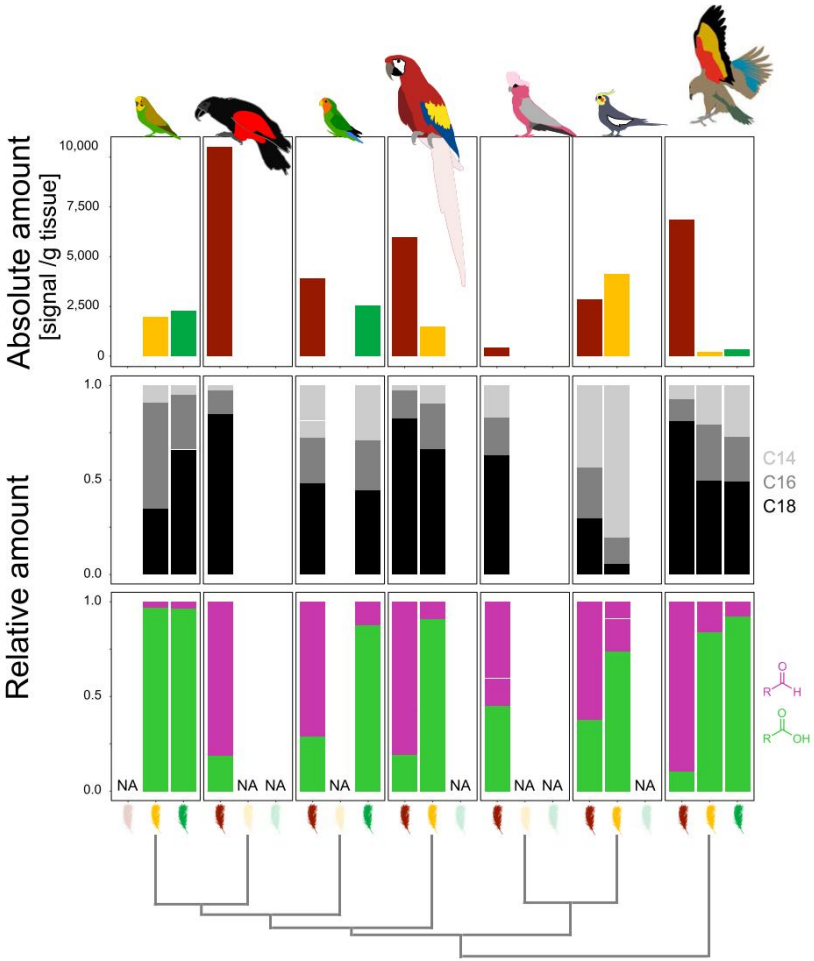
Molecular basis of different colors



Synthesized by a polyketide synthase (PKS)

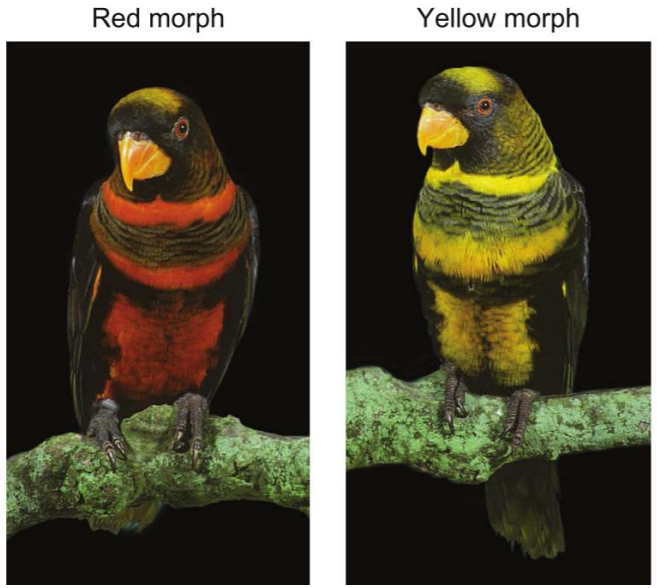


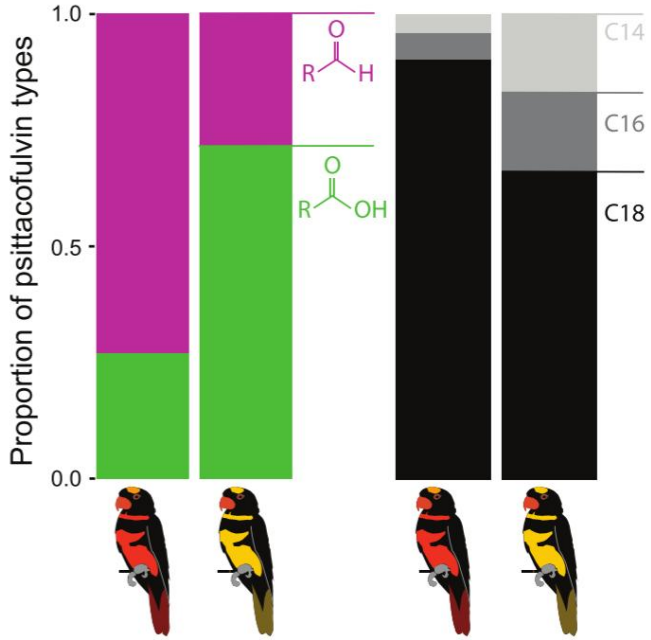


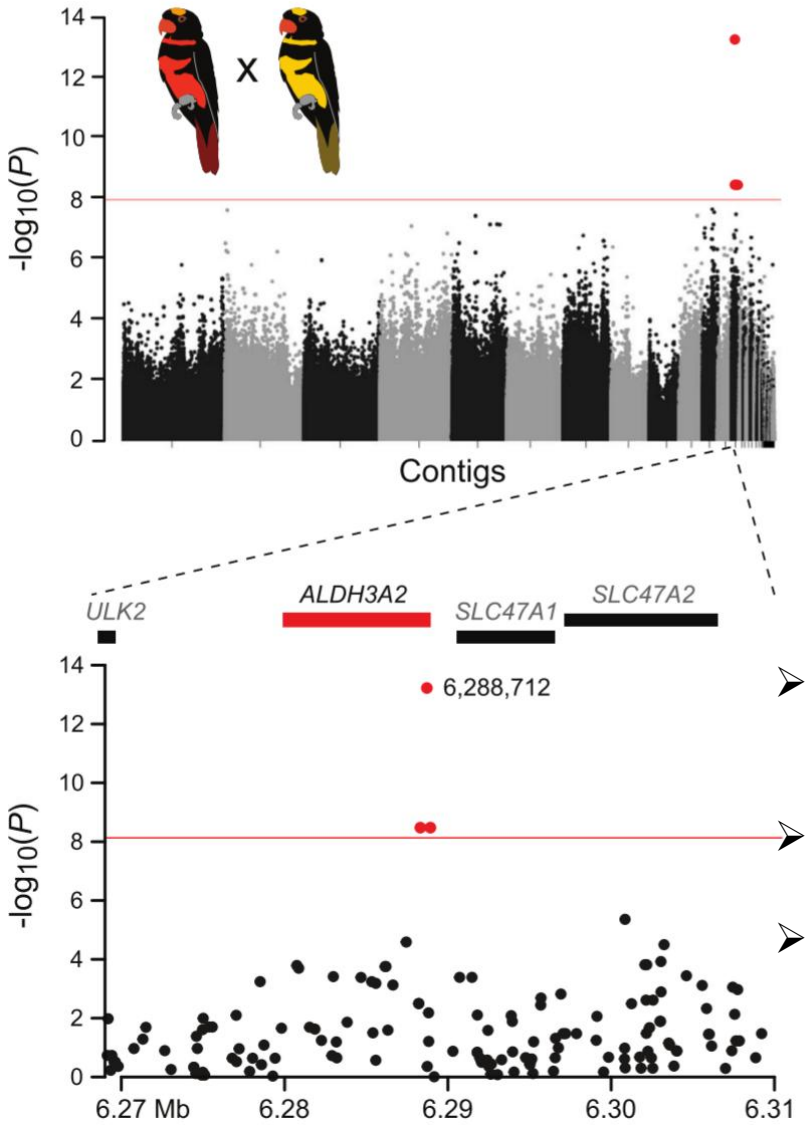


- The more forward peak corresponds to the carboxyl group,
- The more backward peak corresponds to the aldehyde group.
- The peak of red feathers is more forward than yellow/green feathers

Molecular basis of different colors

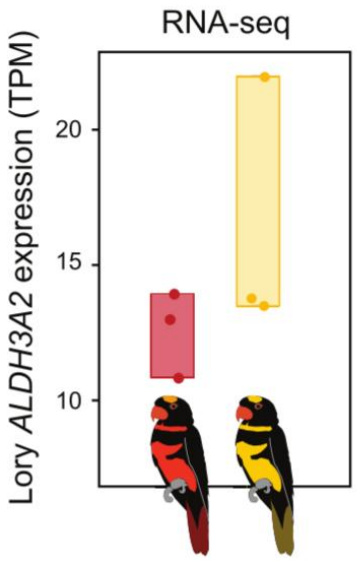


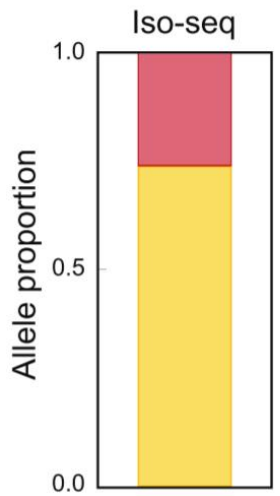


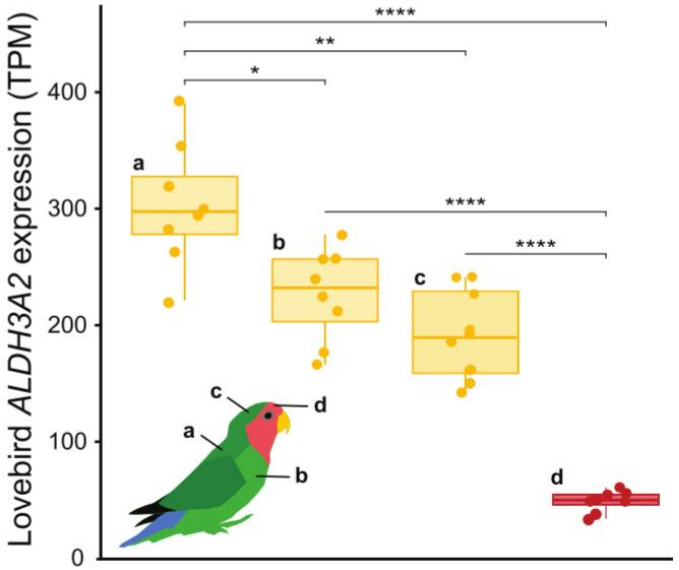


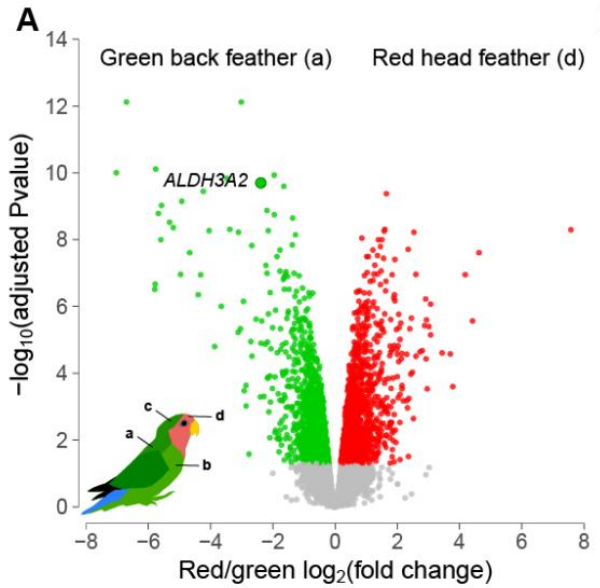
- *SLC47A1* encodes a transporter protein, main function is to excrete electrolytes from the body
- *SLC47A1* expression in regenerating feather follicles is negligible
- *ALDH3A2* encodes an aldehyde dehydrogenase, related to the two states of psittacofulvins

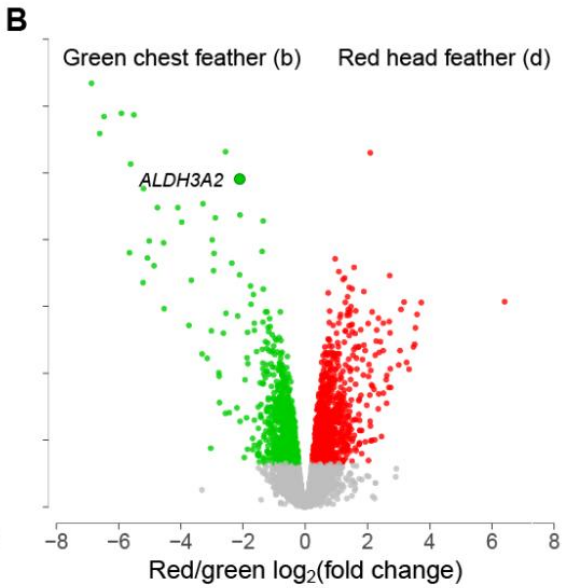
Transcriptome differences between colors

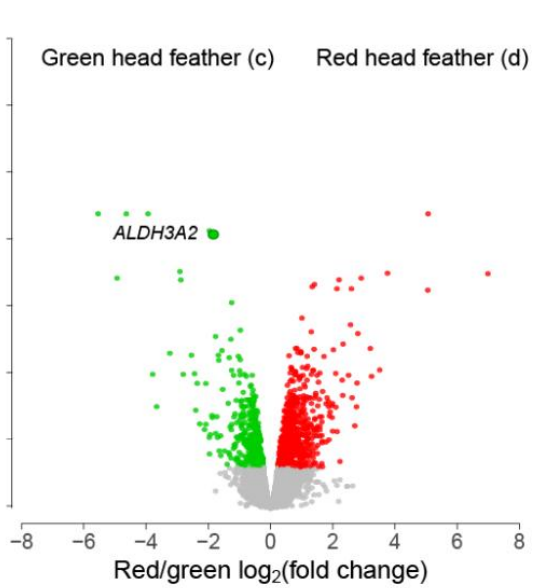




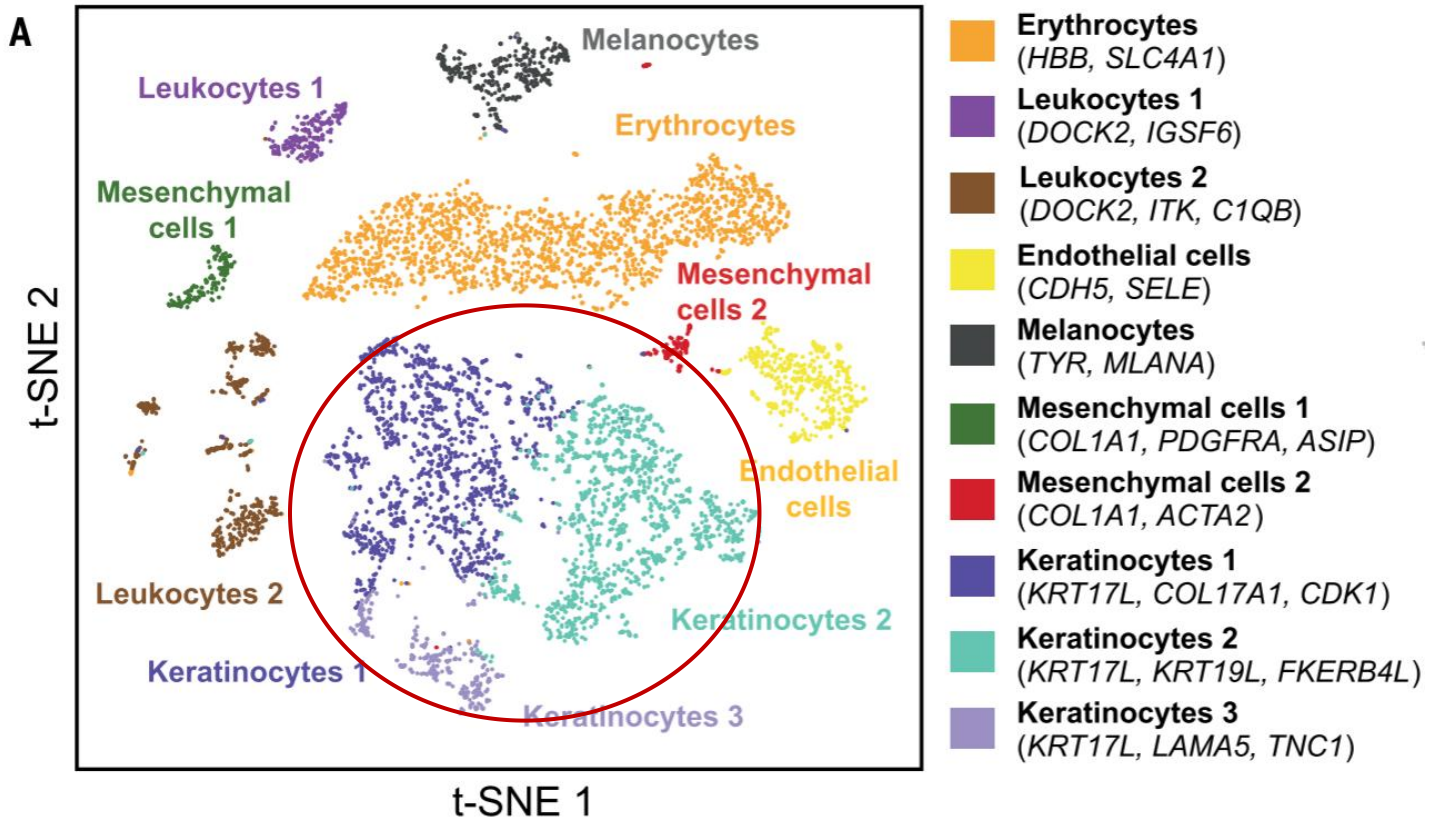


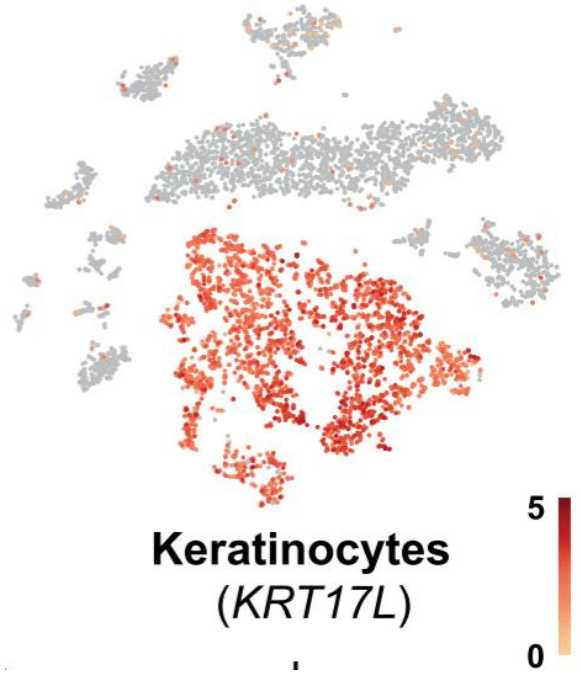




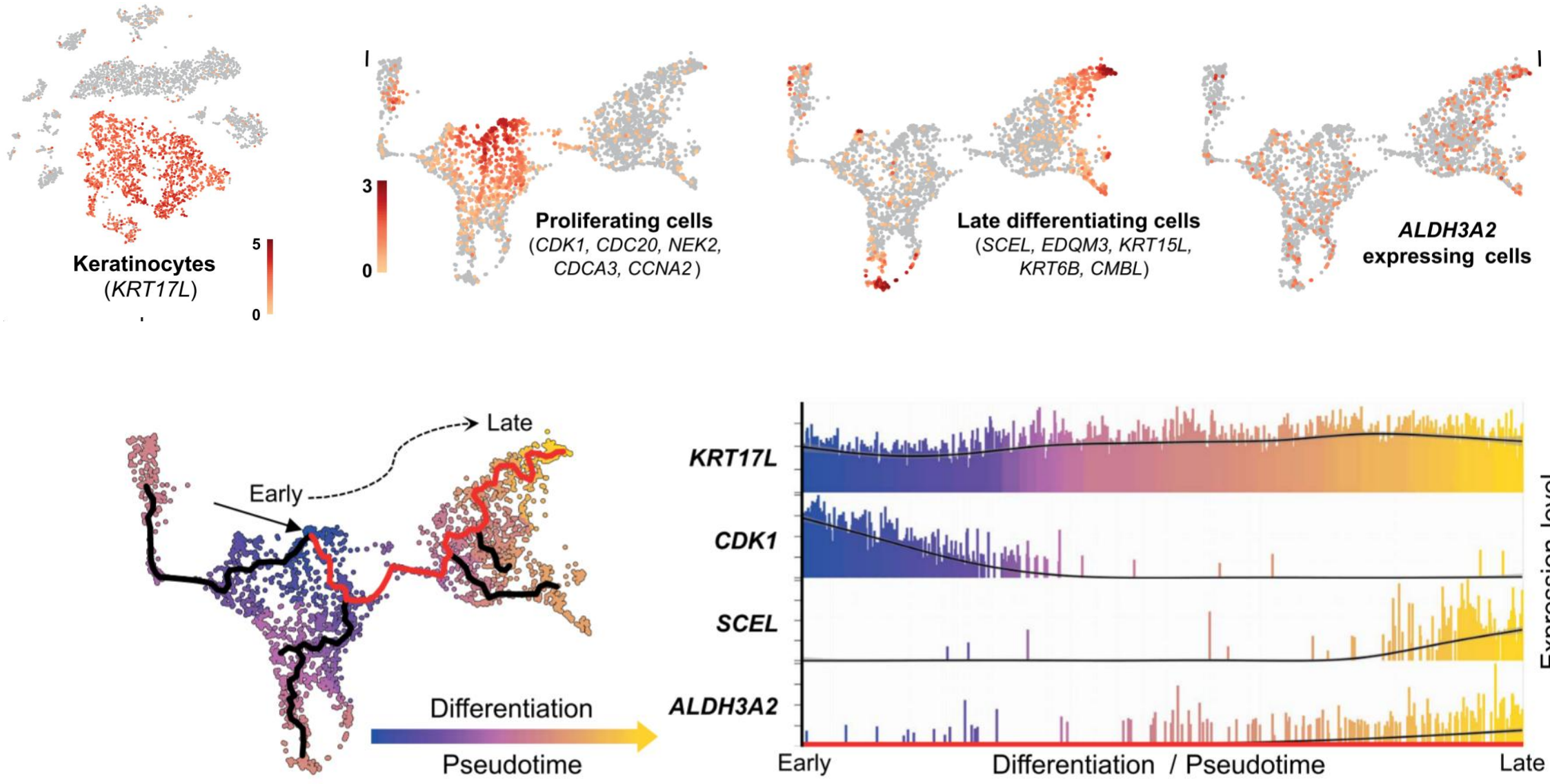


Cell differences between colors

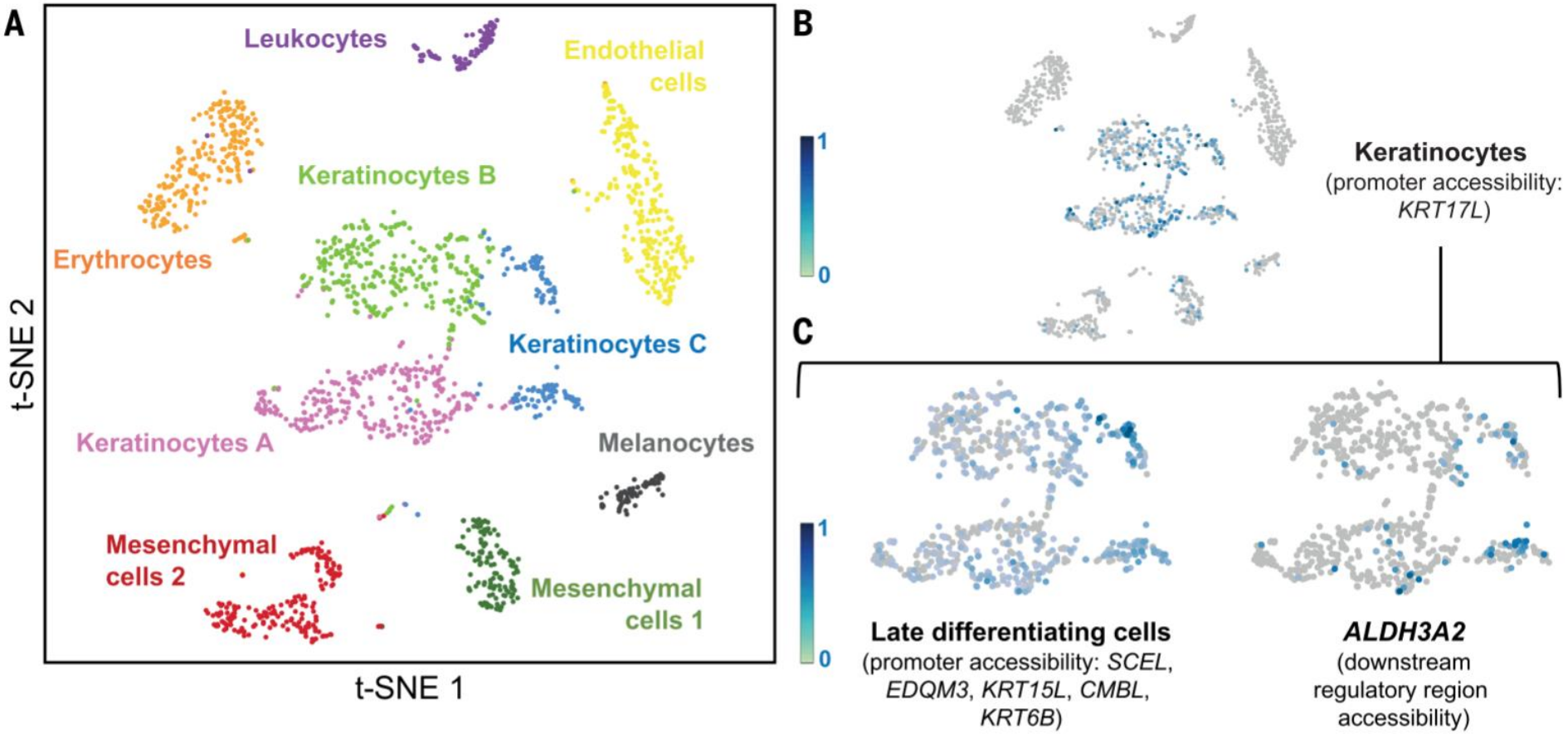




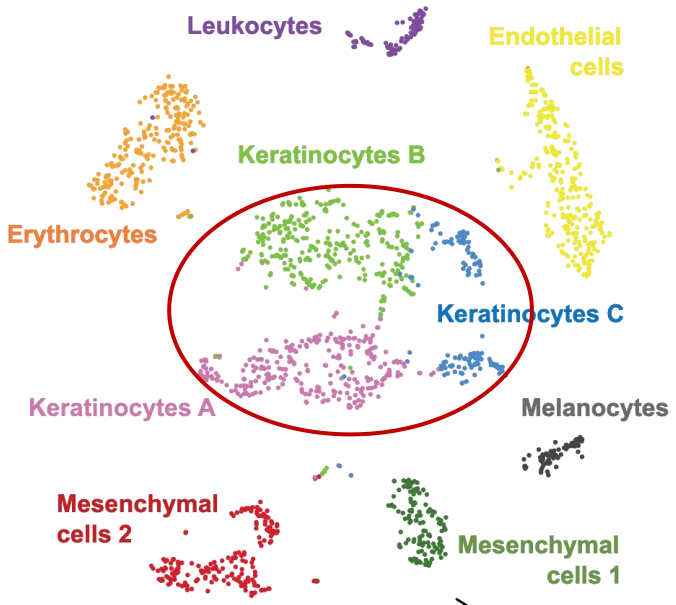
ALDH3A2 gene related to differentiation stage

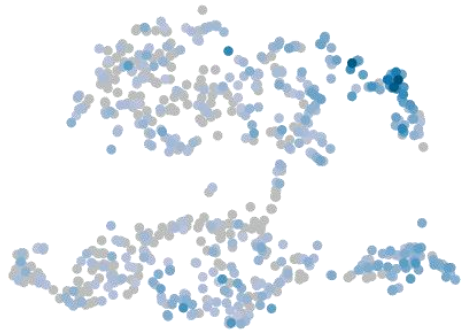


snATAC-seq analyze

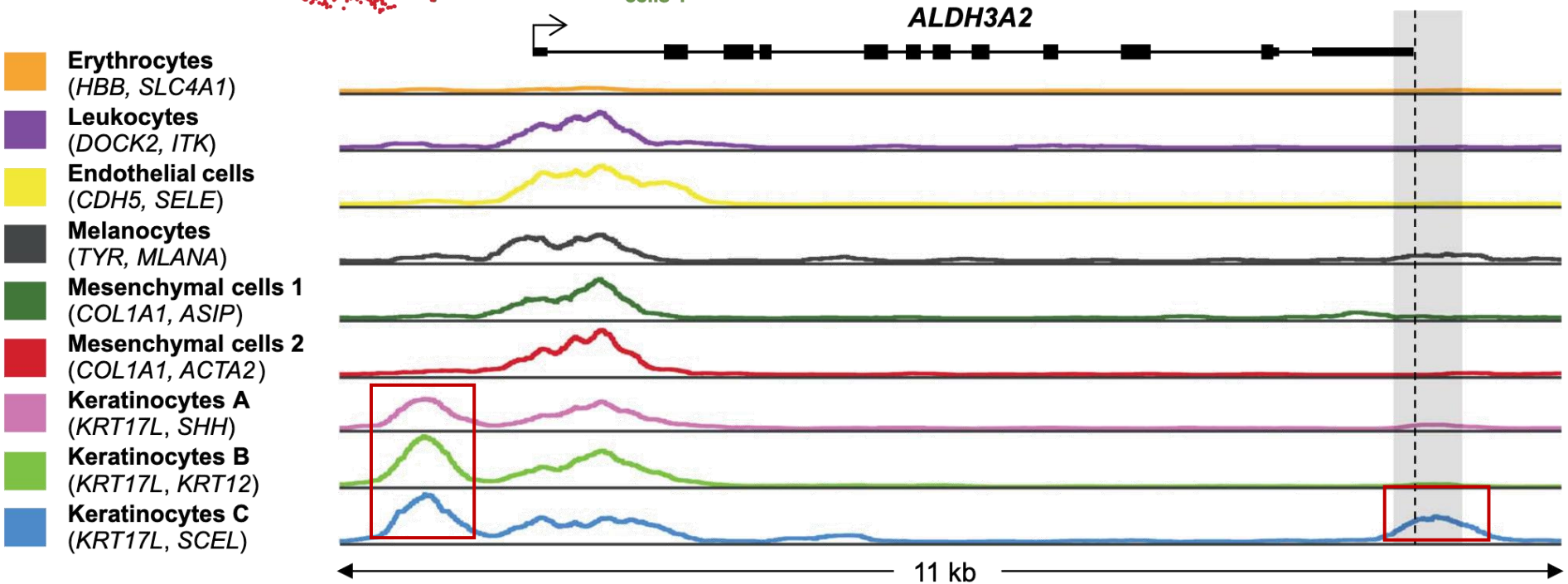


A point mutation causes the color difference





Late differentiating cells
(promoter accessibility: *SCEL*, *EDQM3*, *KRT15L*, *CMBL*, *KRT6B*)



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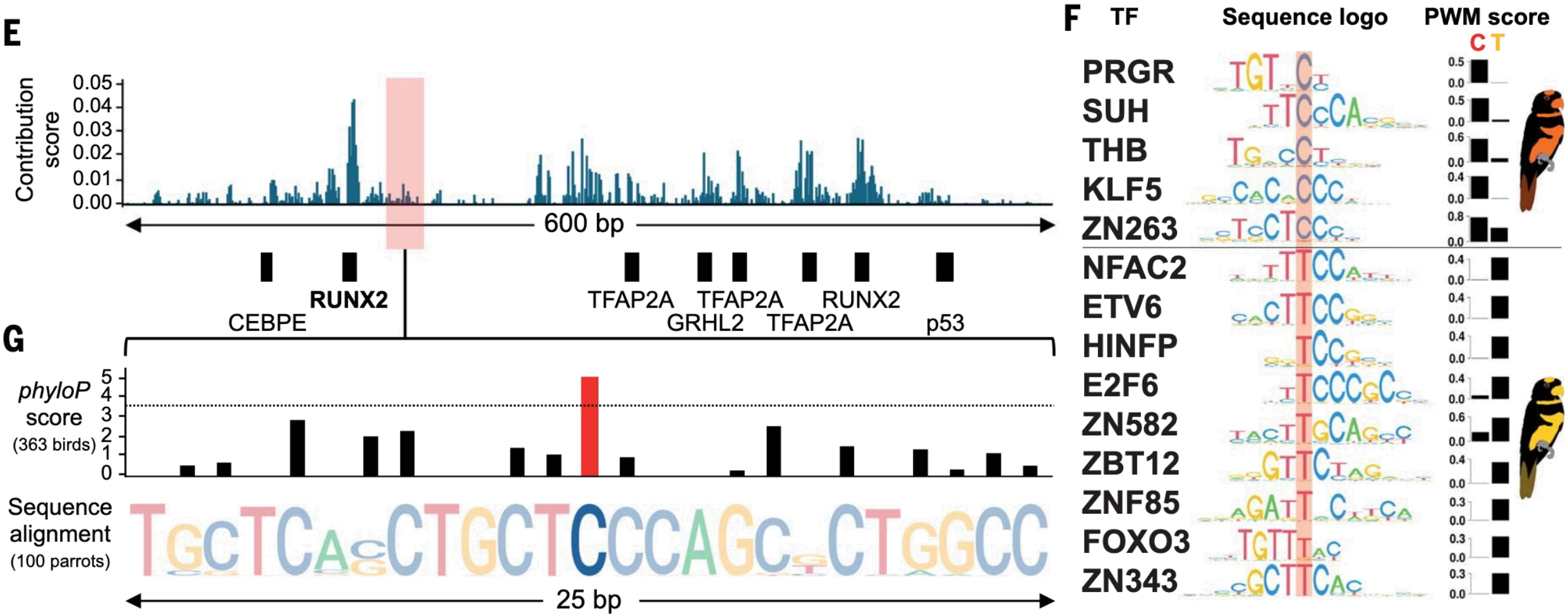
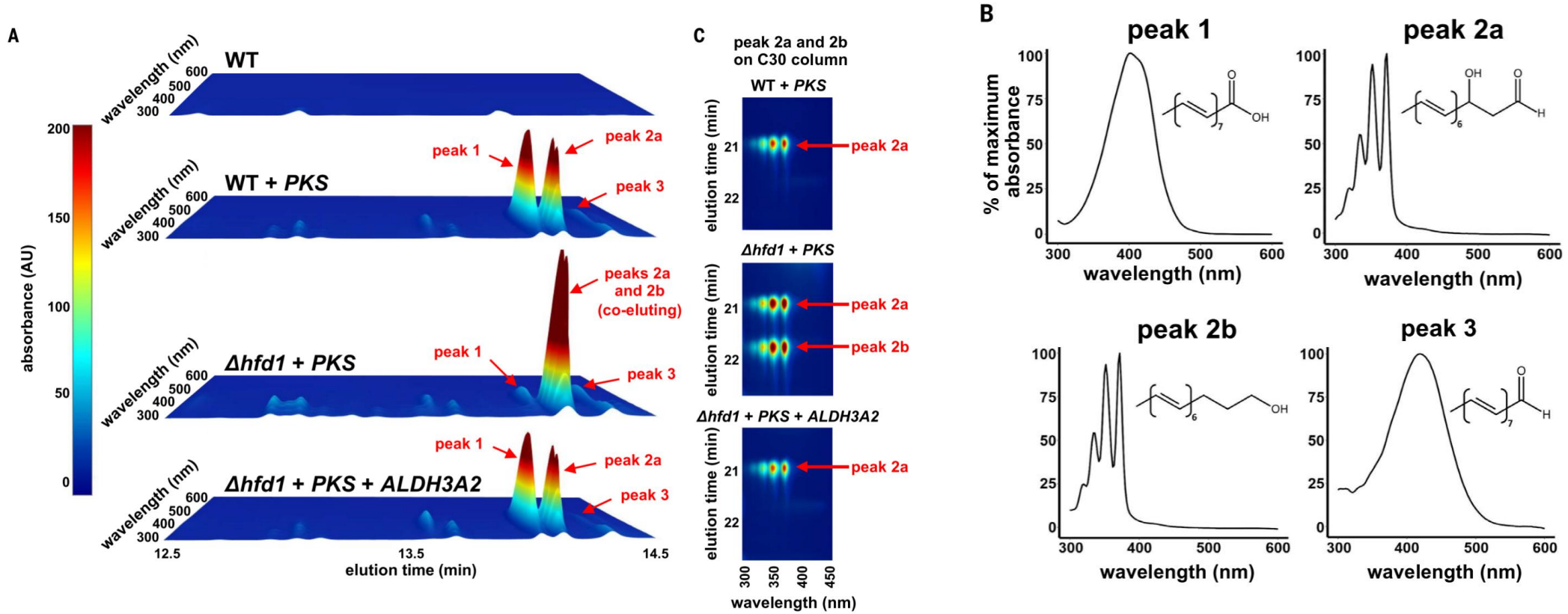
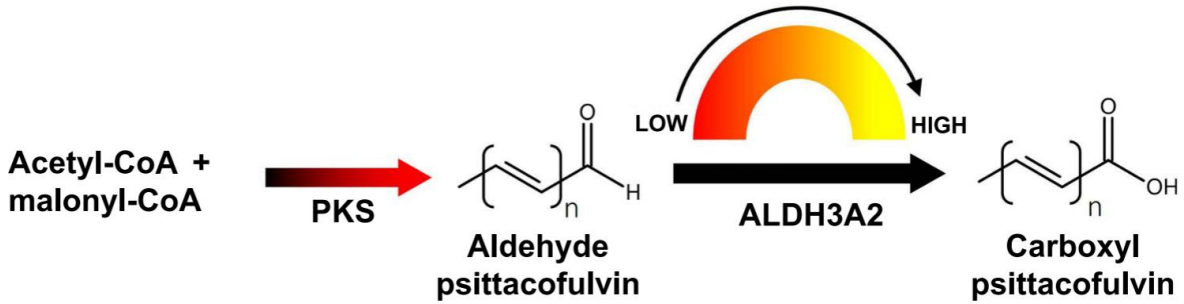


- A deeply conserved enhancer SNP enable the precise regulation of the binding of transcription factors, differentially regulates *ALDH3A2* expression and thereby acts as the molecular switch for red-to-yellow feather in parrots.

Molecular validation by yeast



▲*hfd1* (the homologous gene of *ALDH3A2* in yeast)



Take home message

- The color of parrot feathers is determined by psittacofulvins (red/yellow) and structural colors (blue).
- Psittacofulvins are unique pigments found in parrots, differing from carotenoids and cannot be supplemented through diet.
- When psittacofulvins are rich in aldehyde groups, they appear red; when rich in carboxyl groups, they appear yellow.
- The color transformation of psittacofulvins occurs through the oxidation of aldehyde groups to carboxyl groups, catalyzed by the enzyme ALDH3A2.

Thanks