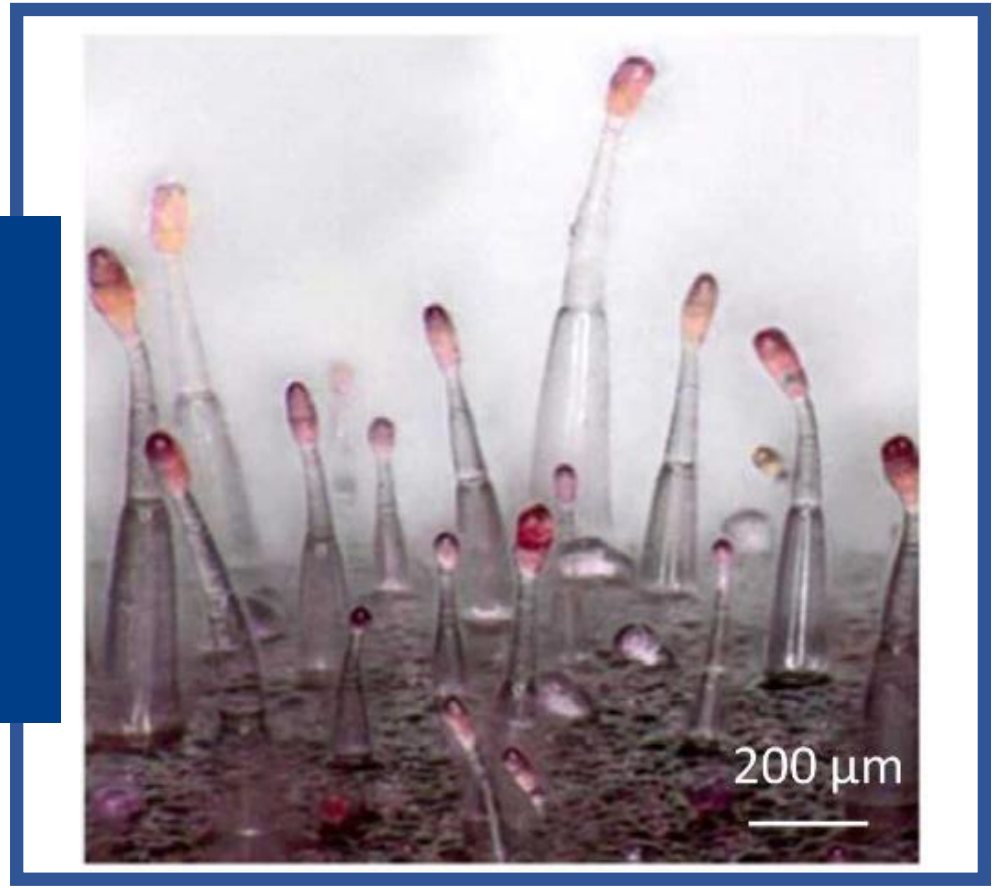
Single-cell transcriptome of *Nicotiana tabacum* leaves reveals developmental trajectories of glandular trichomes

Zhejiang University, China

2022.10



Song et al, 2018

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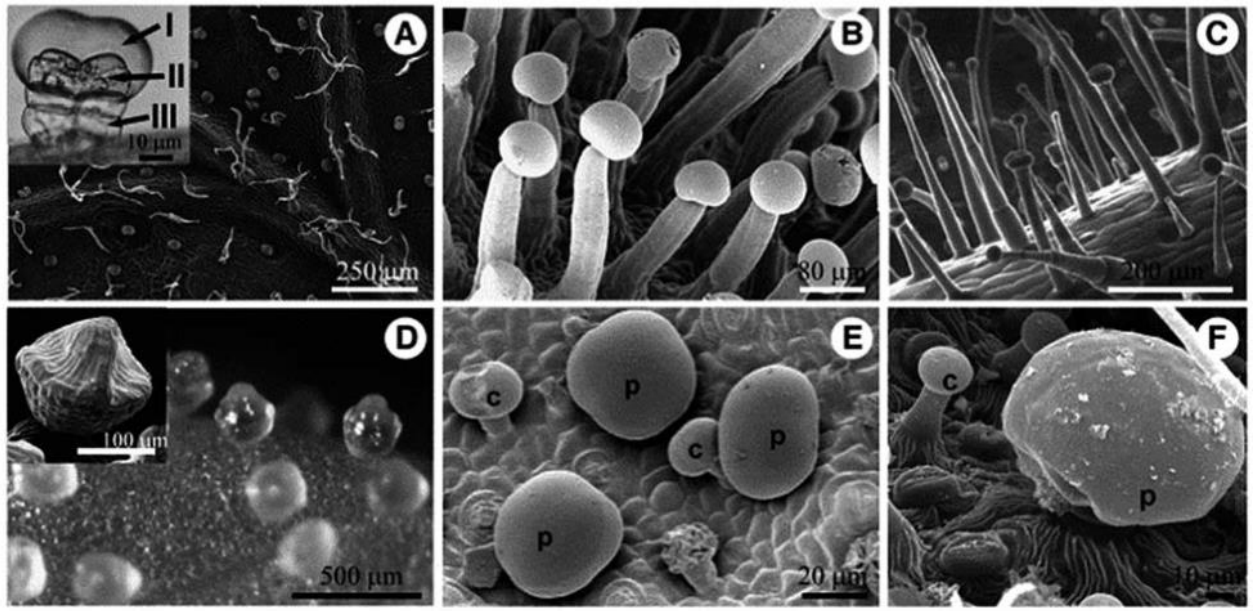
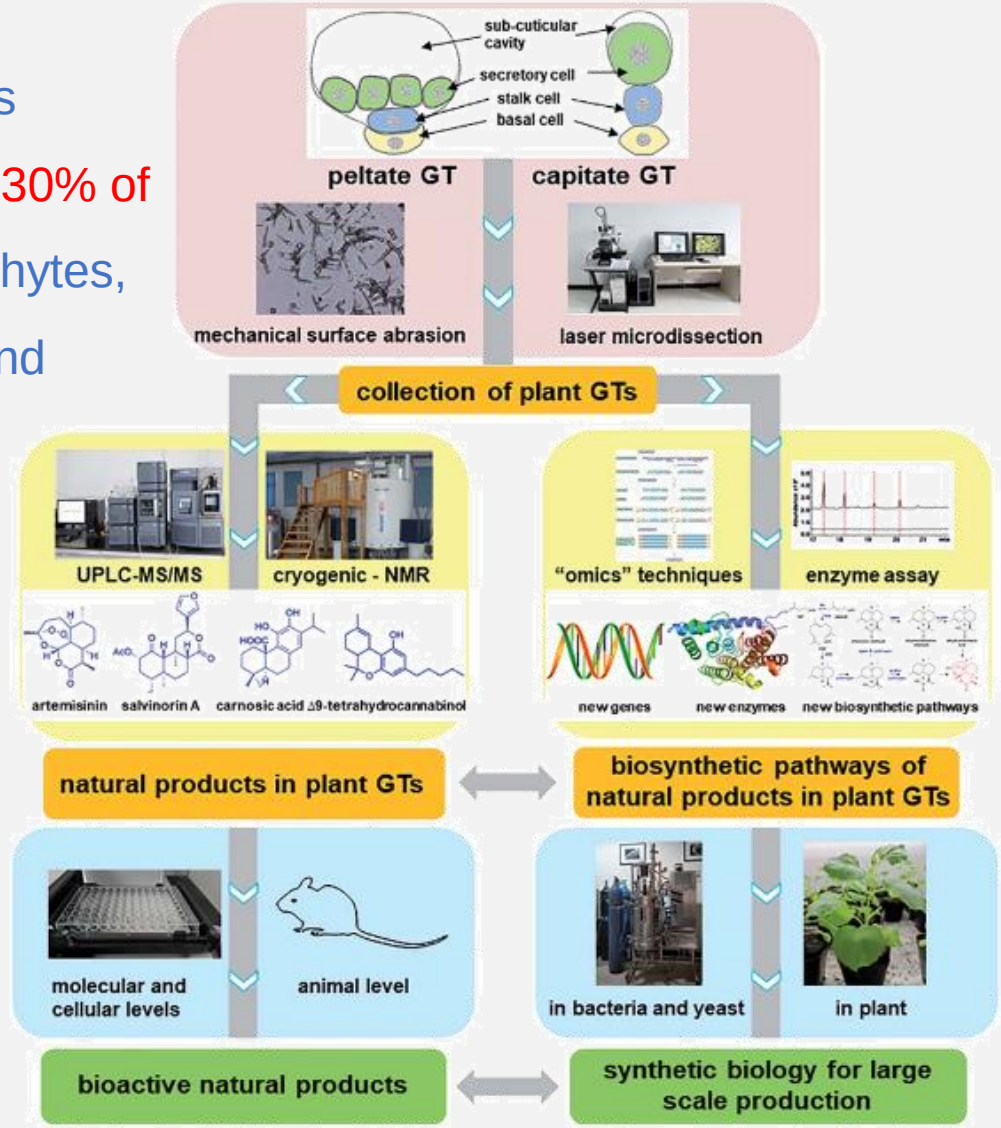
Glandular trichomes -- "phytochemical factories"

Plant glandular trichomes (GTs) are specied epidermal structures distributed on the surfaces of the aerial organs of approximately 30% of vascular plants, including angiosperms,gymnosperms and bryophytes, and play important roles in plant resistance against herbivores and pathogens and in plant environment interactions.





Liu et al, 2019

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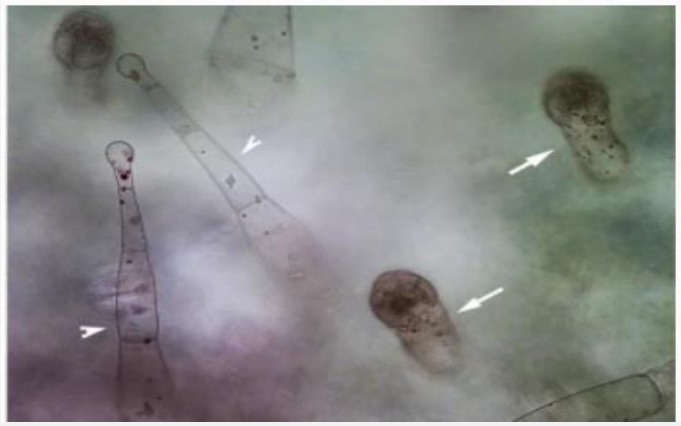
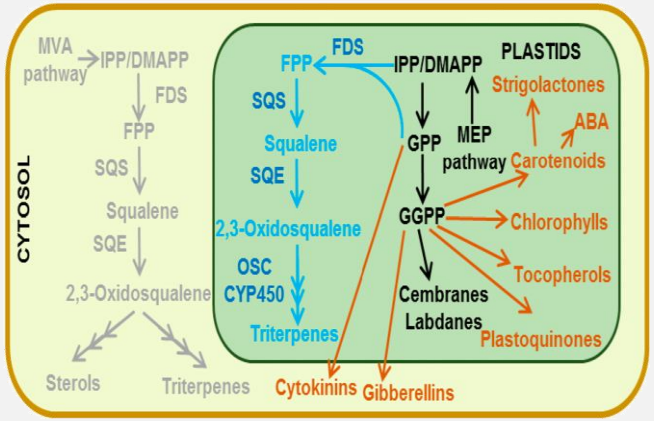
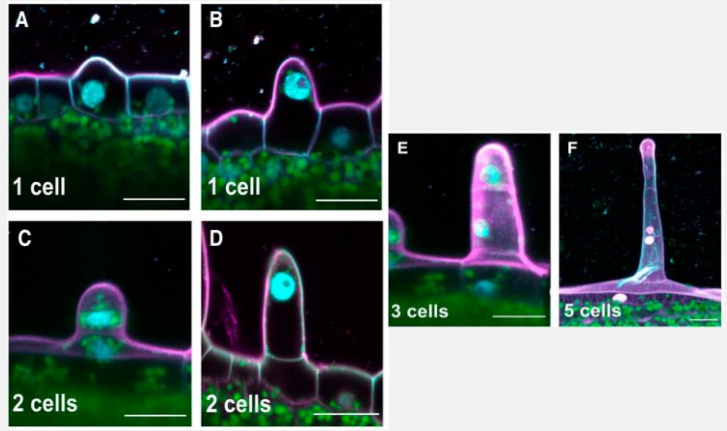
Glandular trichomes of *Nicotiana tabacum*







Types of Glandular Trichome

1. Tall glandular trichome
2. Short glandular trichome
(also covered with single uniseriate nonglandular trichomes)

Secondary Metabolites of Glandular trichome

1. Nicotine is synthesized in the root and transported into short glandular trichome
2. Influence leaf aroma and smoke flavor

Development of Glandular Trichomes

1. A greatly asynchronous trichome development
2. Trichome production and maturation is limited to short periods early in leaf development

Huchelmann et al., 2017

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Reveal development of glandular trichomes by scRNA-seq

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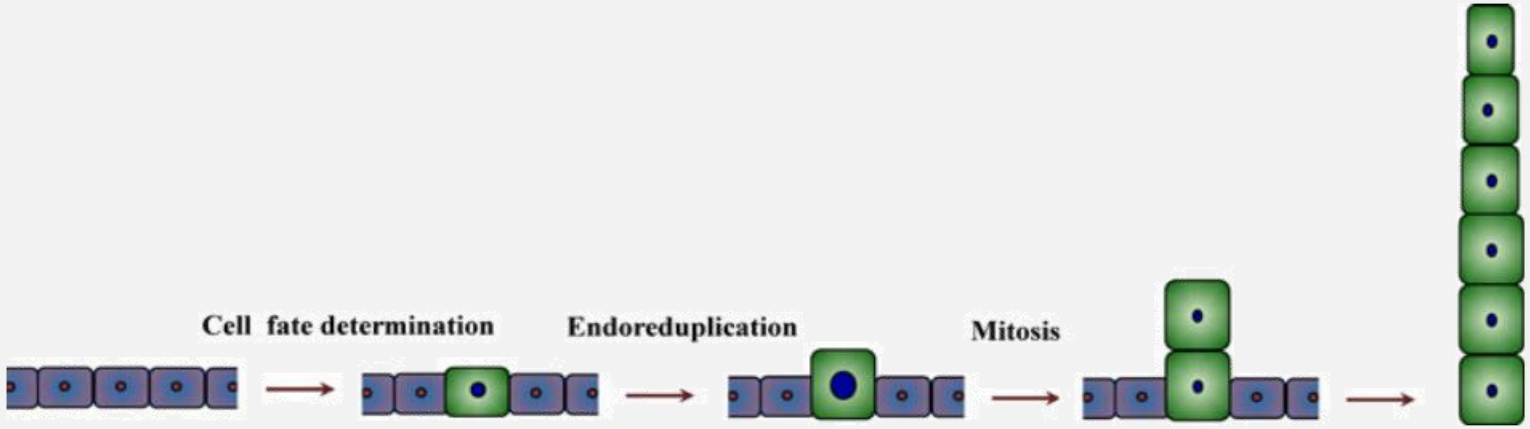
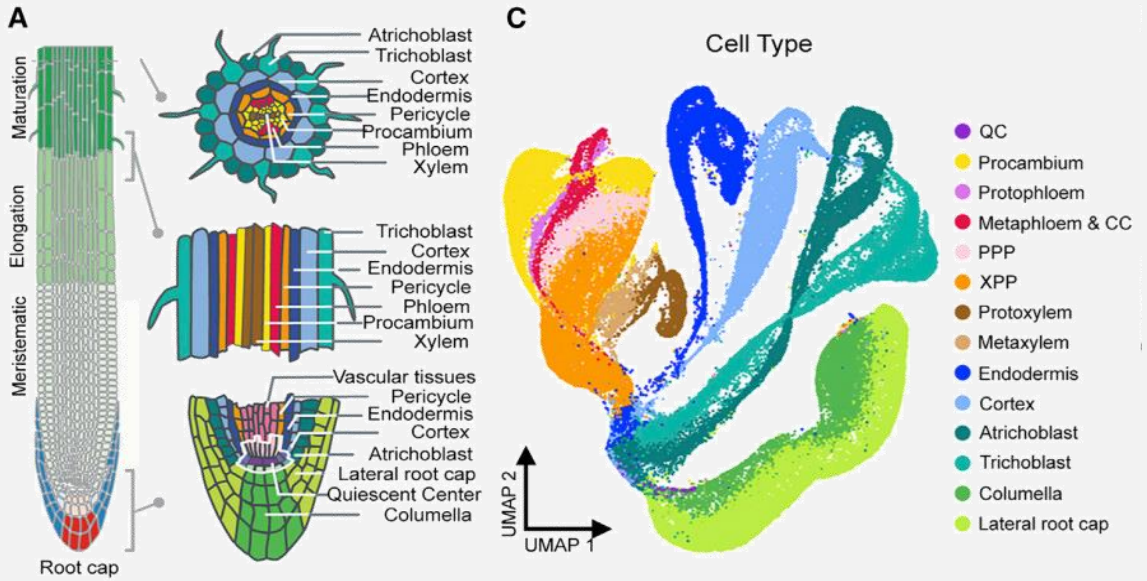


Reconstructing developmental trajectories of glandular trichome using captured cells at different developmental stages



Zhang et al., 2019

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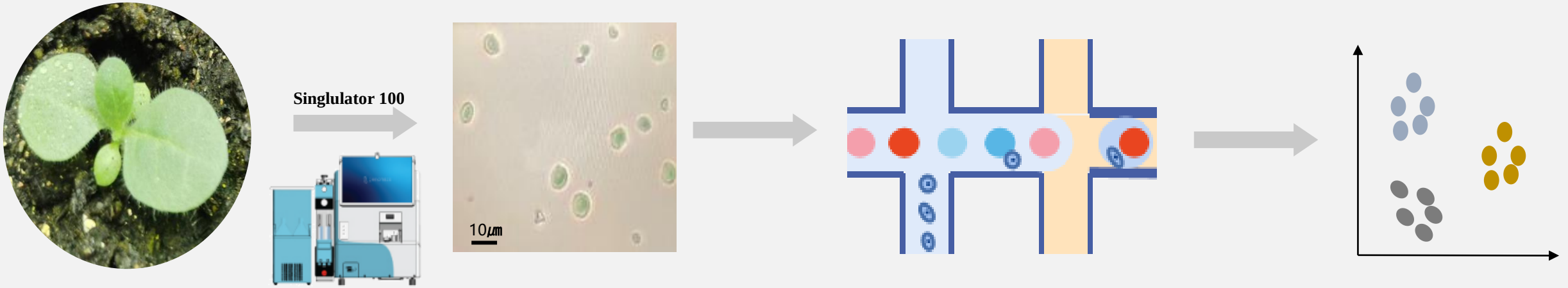
Reveal development of glandular trichomes by scRNA-seq

"For example, we found that the leaf trichome cells are resistant to protoplasting,and we were unable to recover single trichome protoplast cells for downstream analysis"

(Zhang et al., 2021)



Automatic nuclear extraction system

10X Genomics microfluidic system

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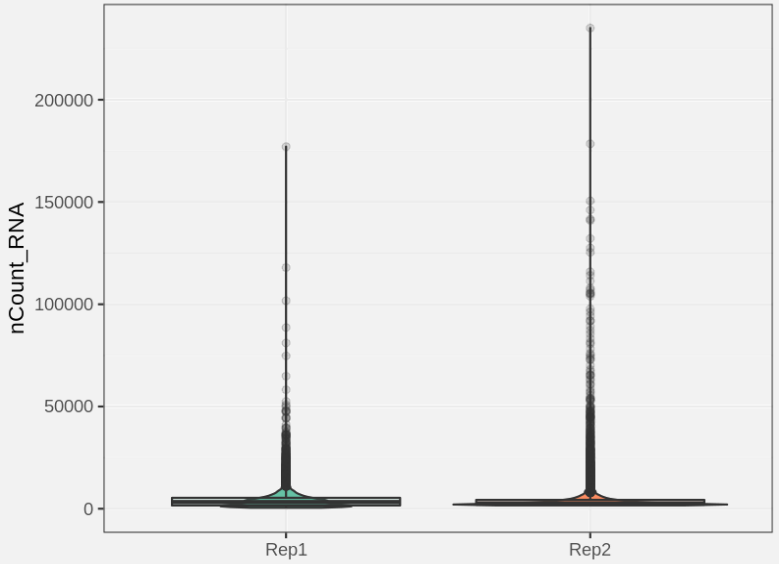
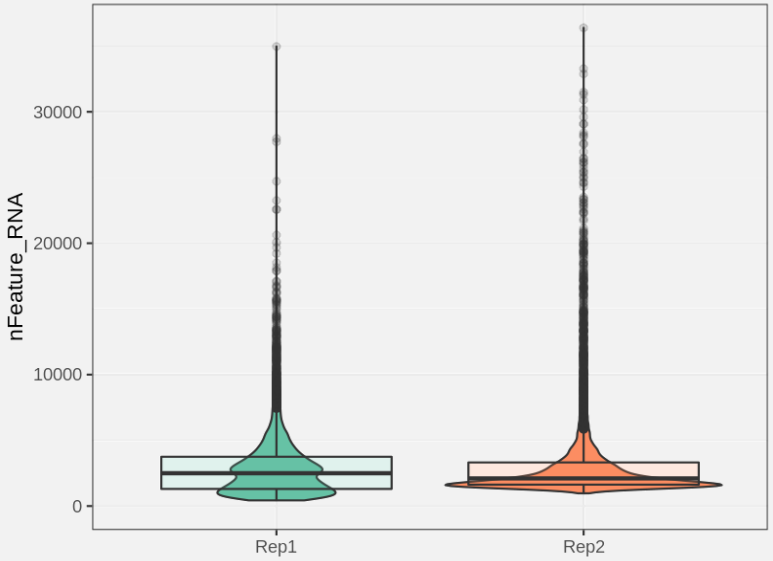
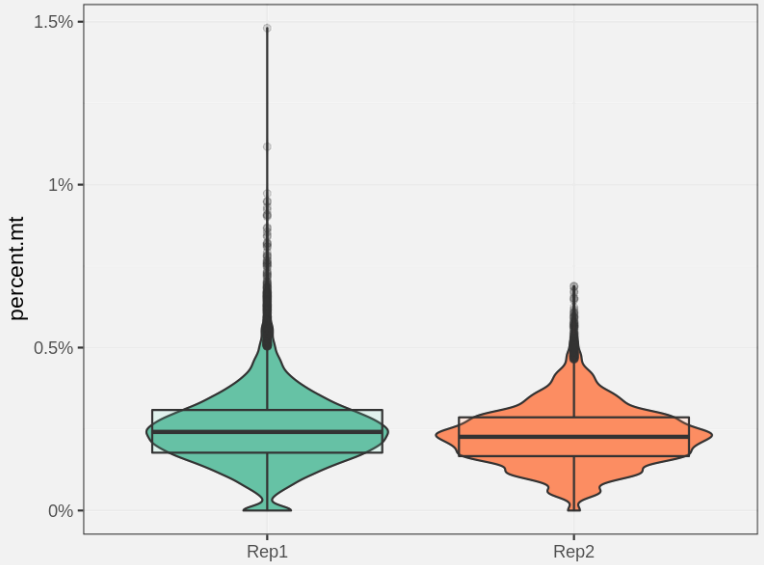
Reveal development of glandular trichomes by scRNA-seq

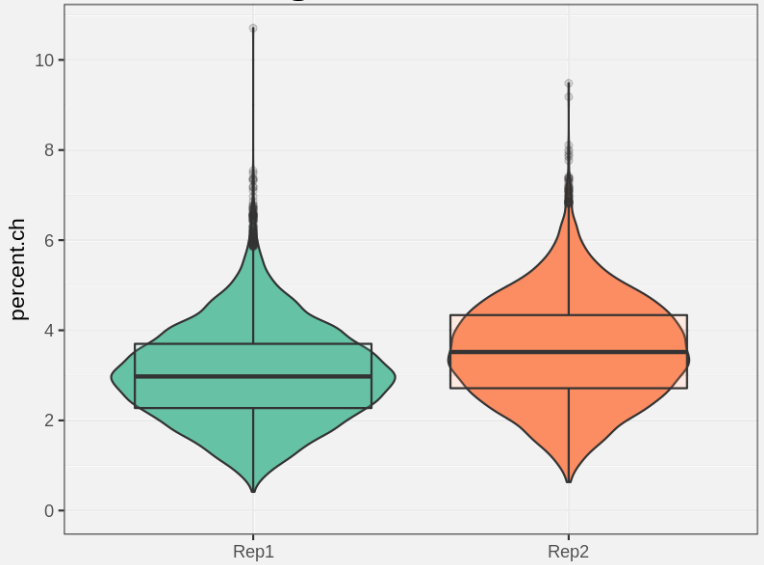


the amount of RNA detected in each cell



the number of genes detected in each cell





the ratio of mitochondrial and chloroplast genes in each cell

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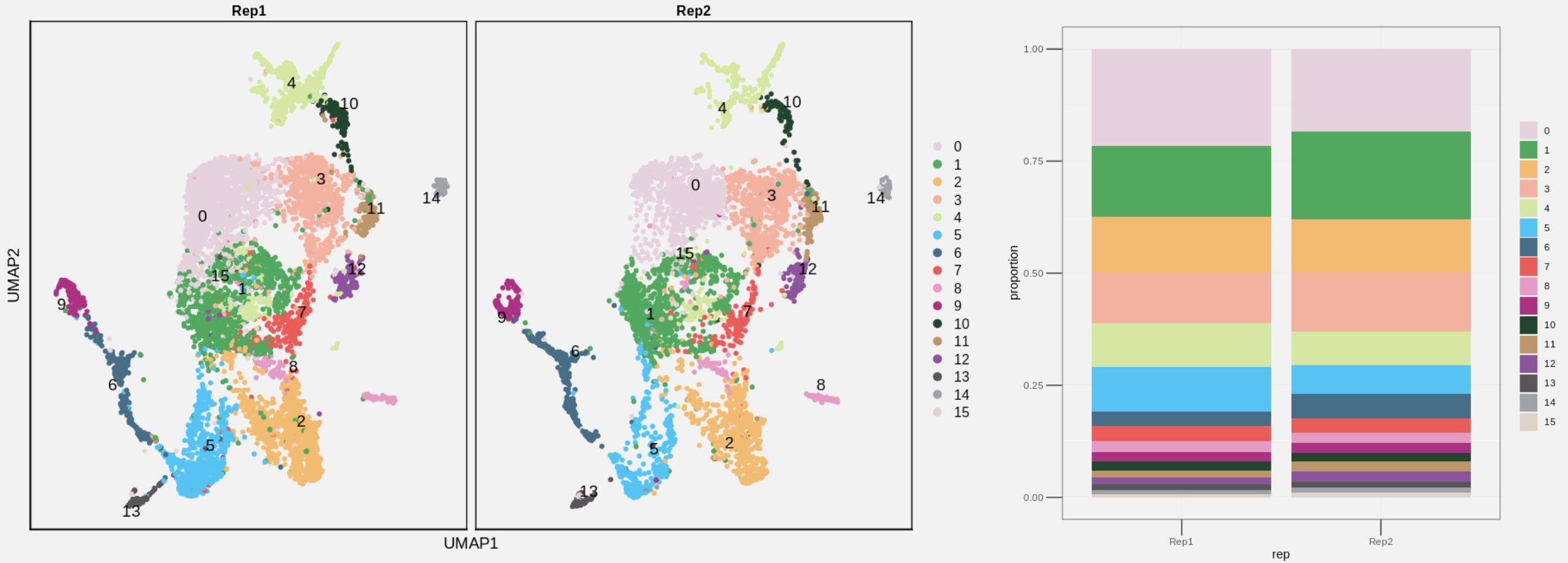
Reveal development of glandular trichomes by scRNA-seq



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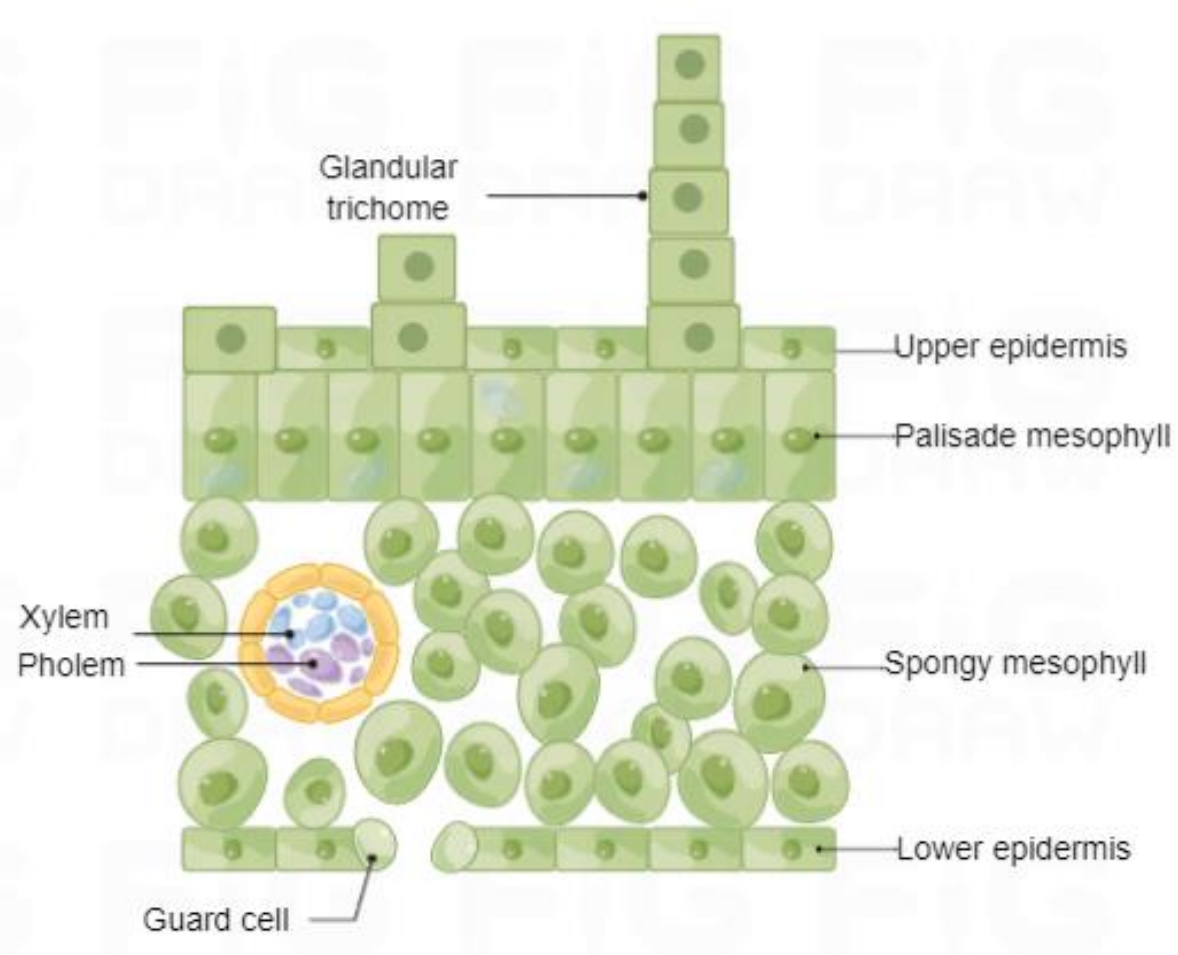
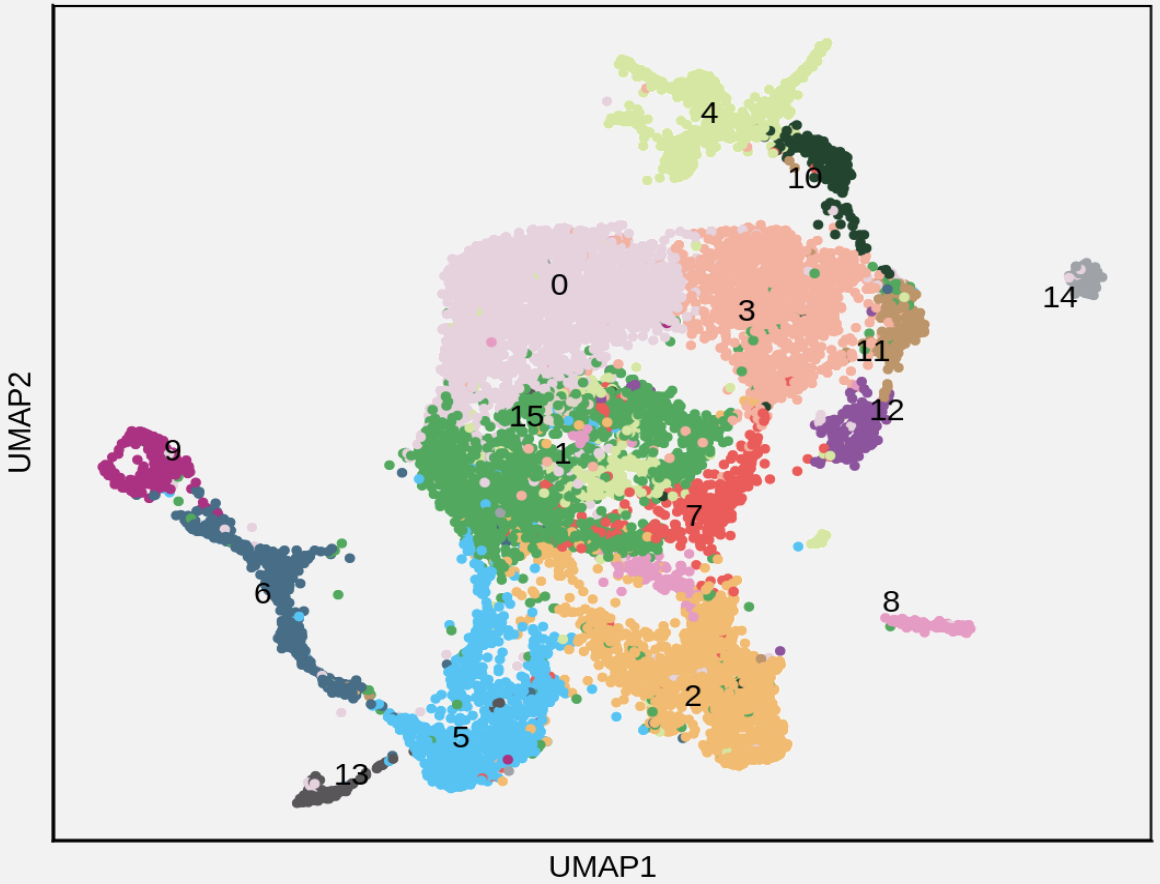
Reveal development of glandular trichomes by scRNA-seq





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Reveal development of glandular trichomes by scRNA-seq

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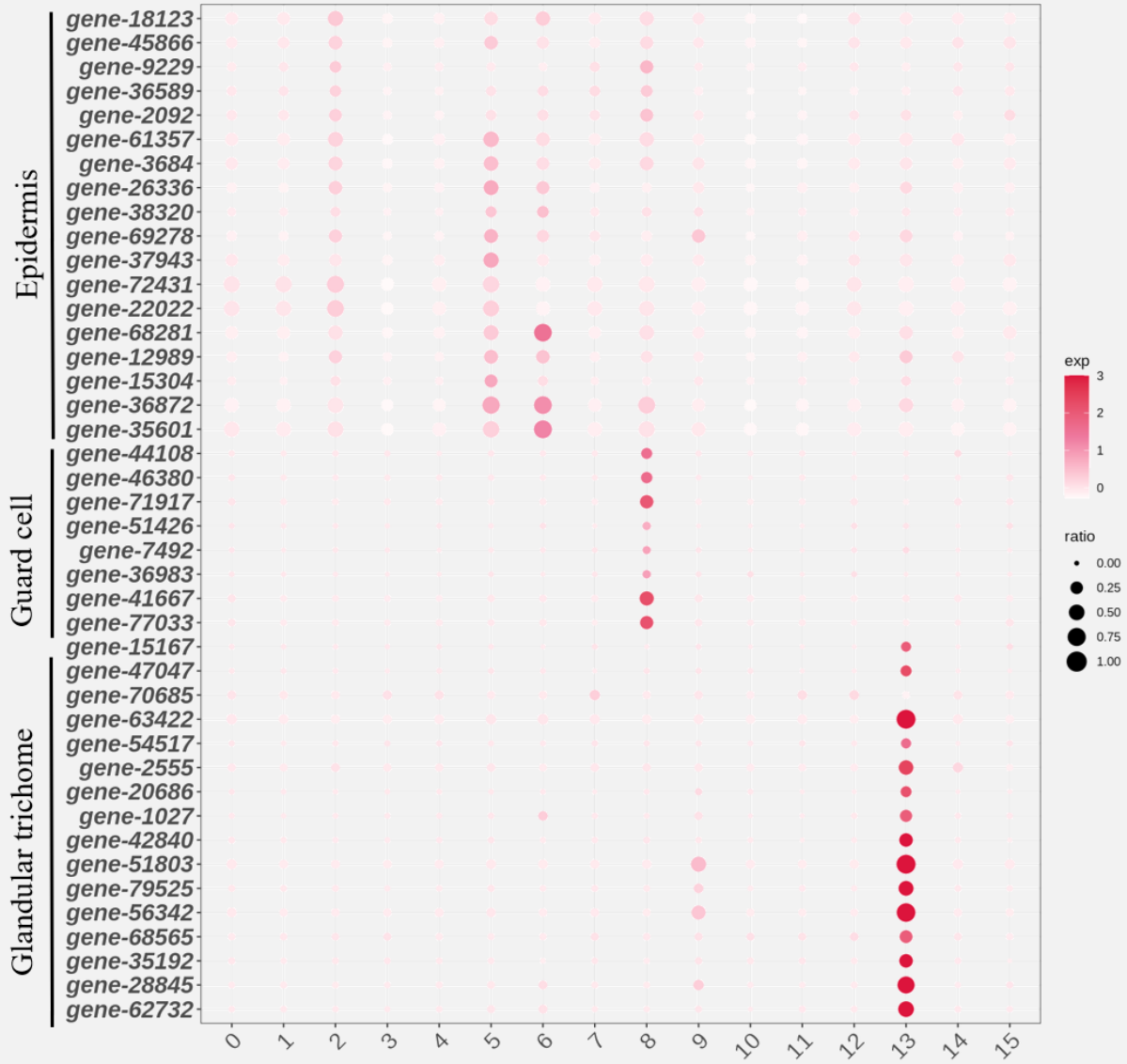

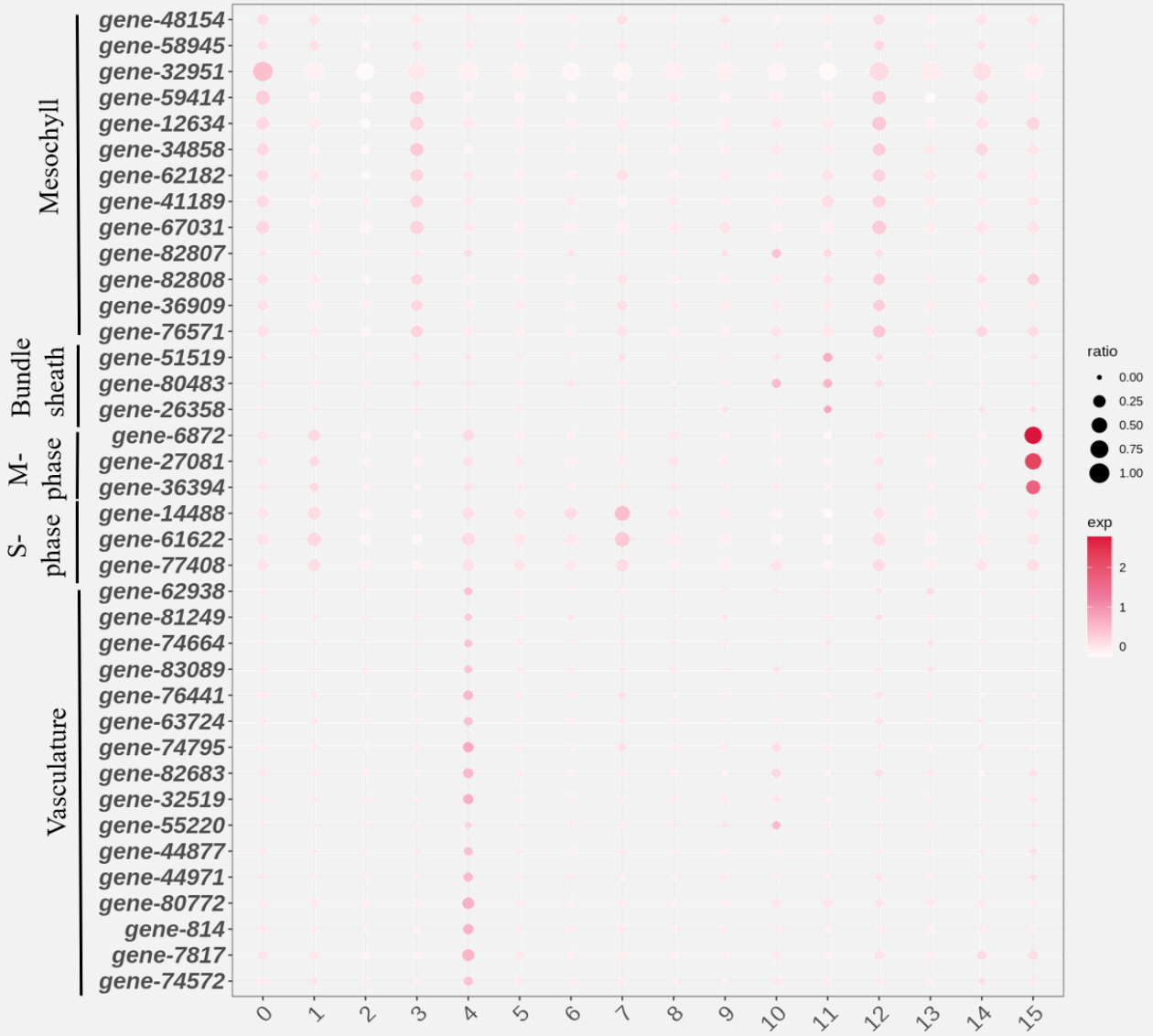

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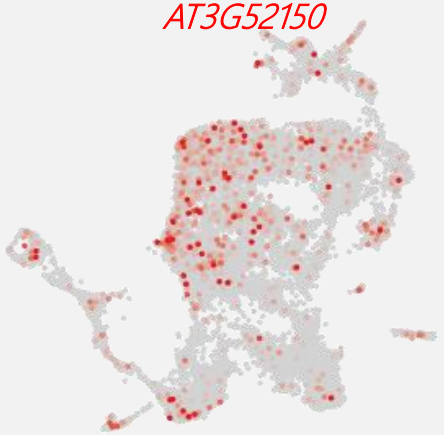
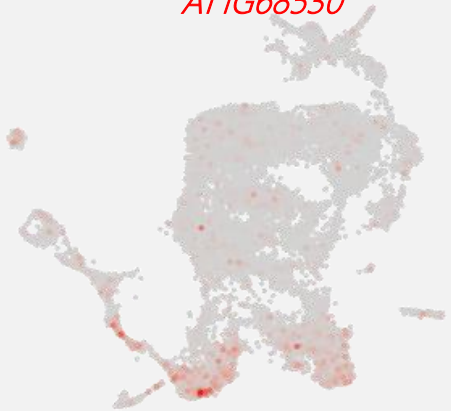
Reveal development of glandular trichomes by scRNA-seq

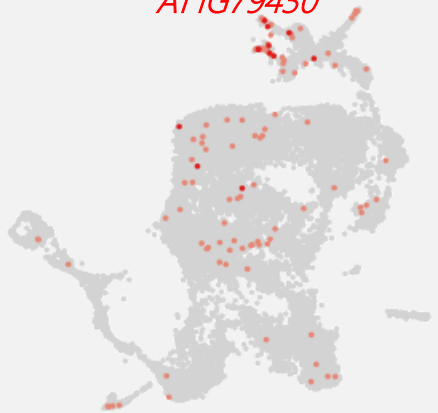
gene-59391
AT3G52150



gene-26336
AT1G68530



gene-62938
AT1G79430



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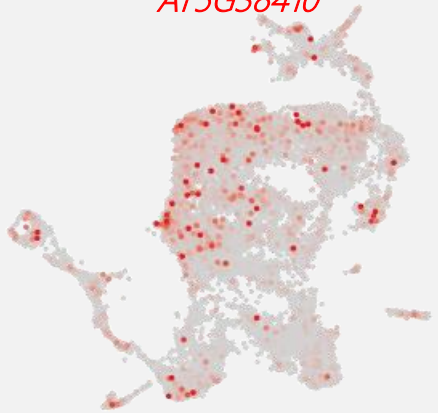
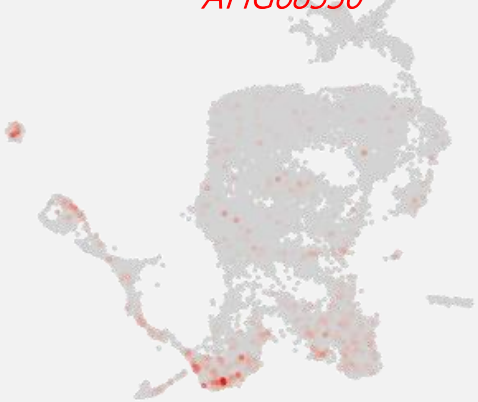
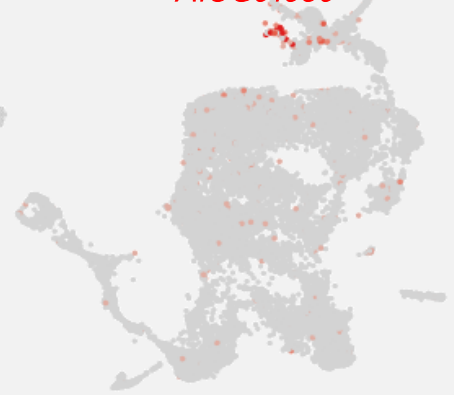
AT5G38410



gene-69278
AT1G68530



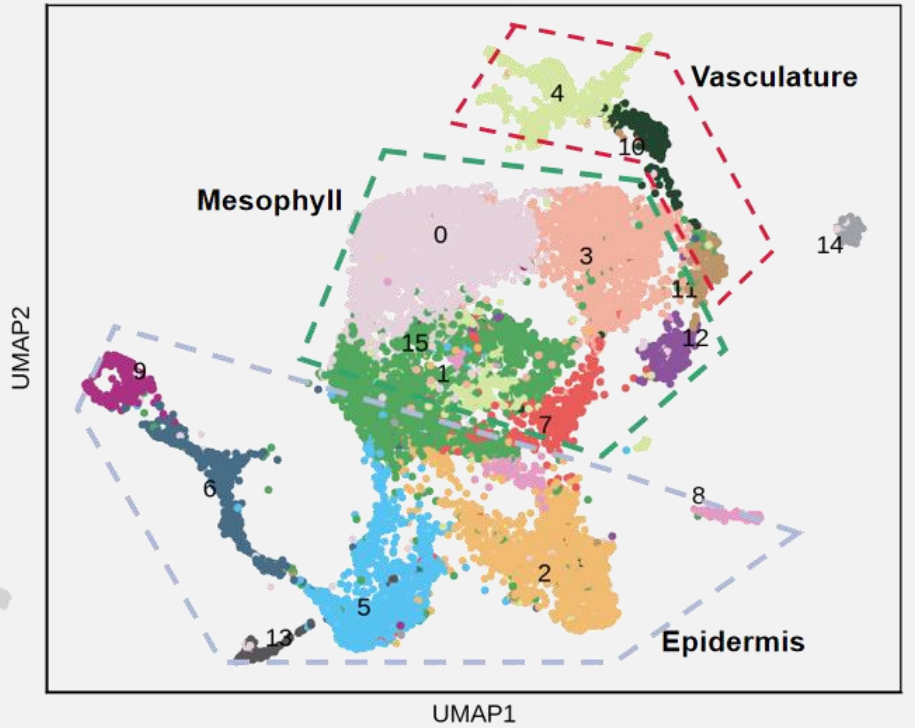
gene-15796
AT3G01680



Mesophyll marker

Epidermis marker

Vasculature marker



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Reveal development of glandular trichomes by scRNA-seq

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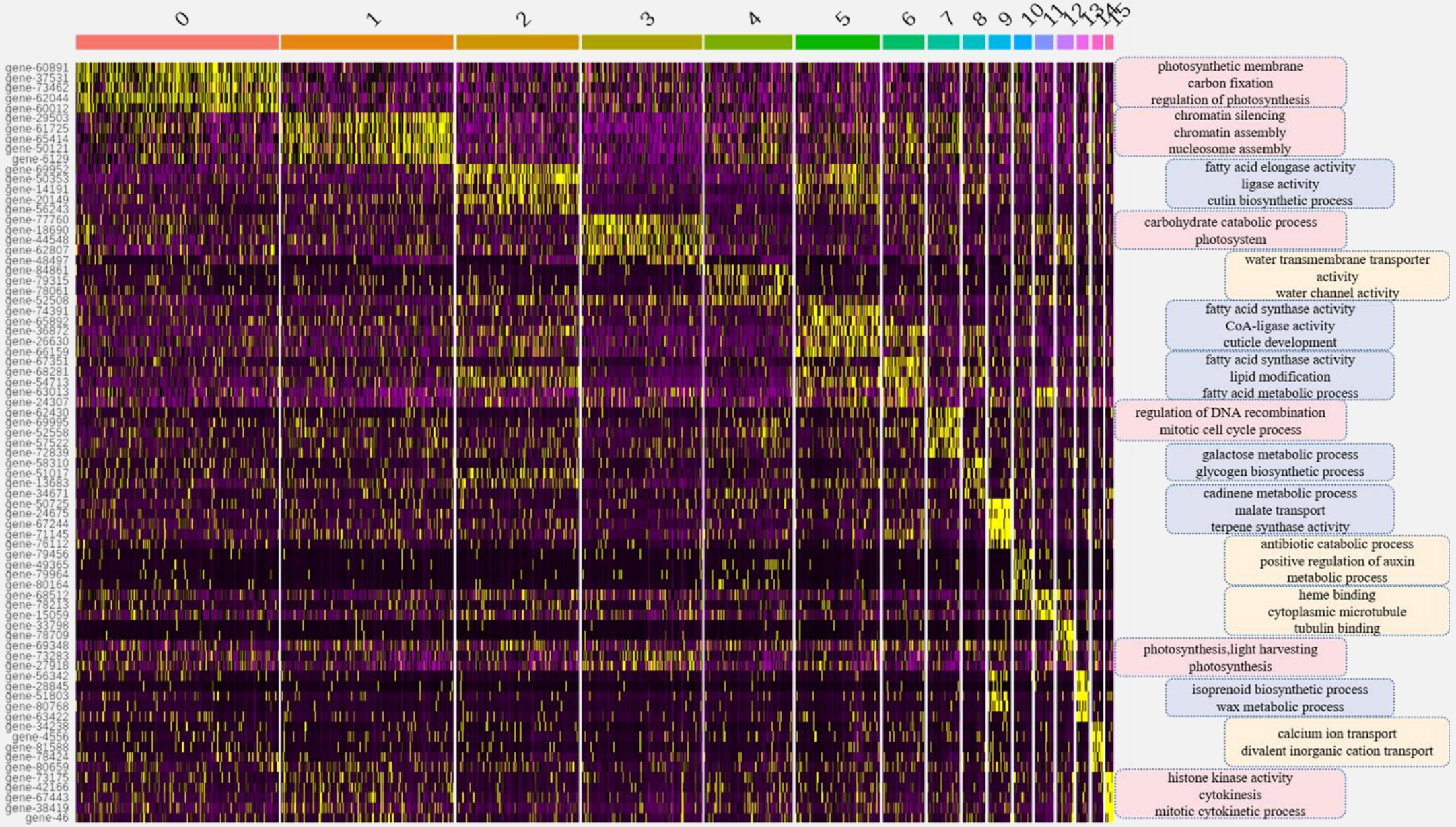

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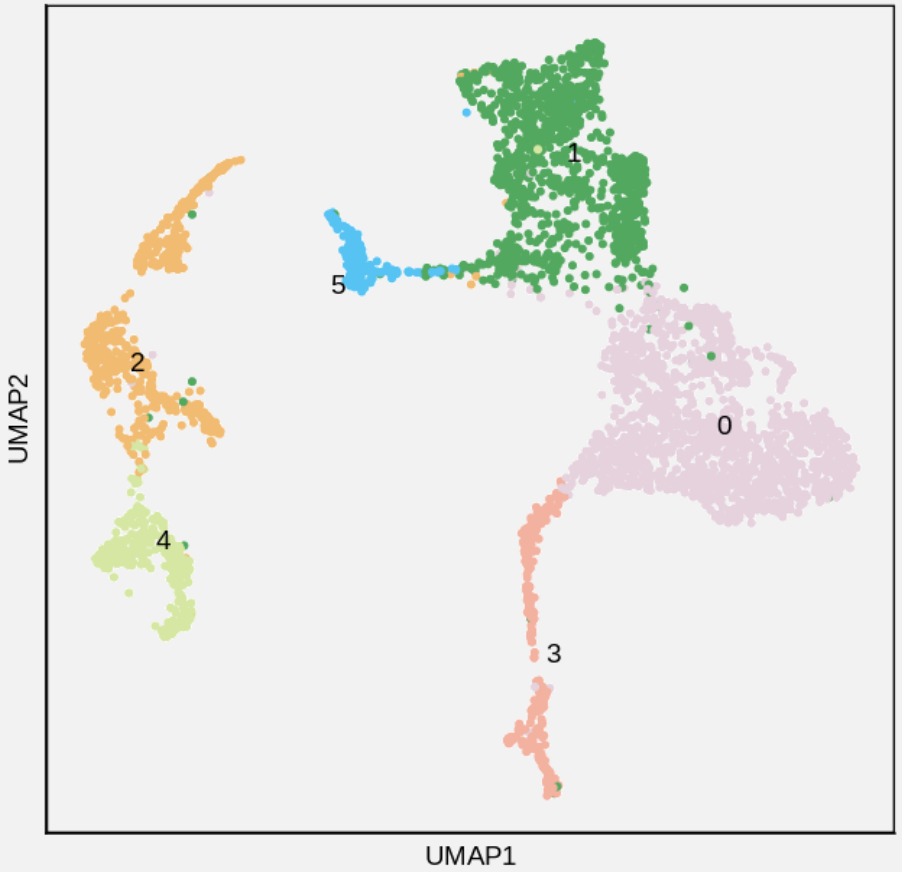
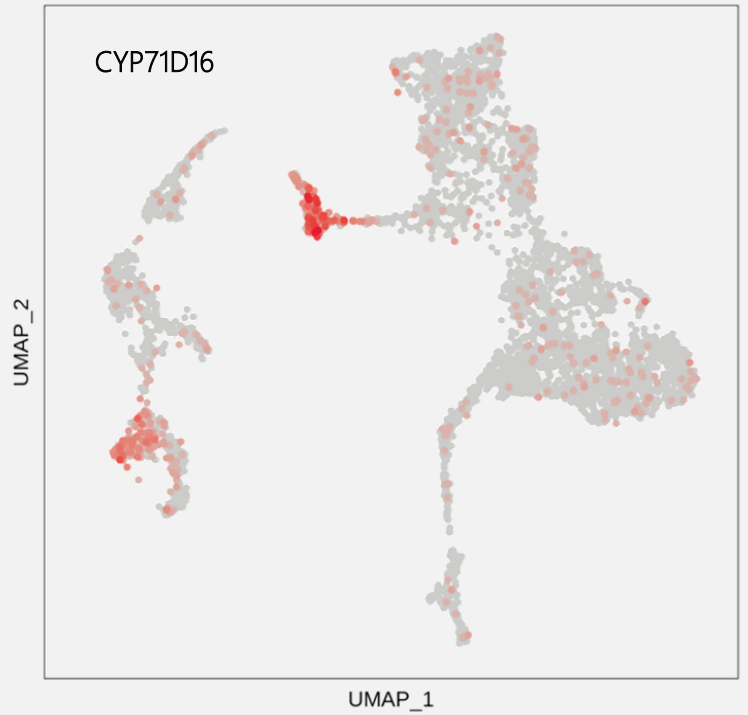
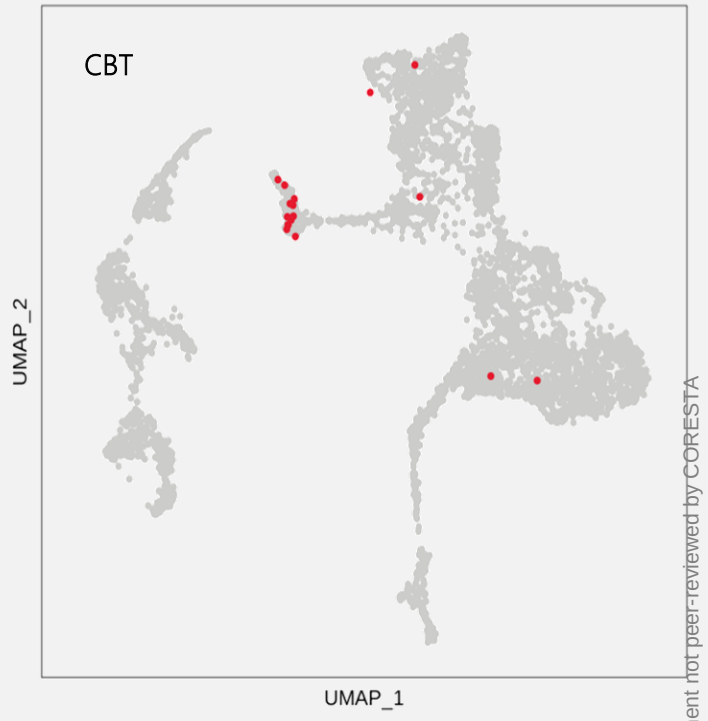
Reveal development of glandular trichomes by scRNA-seq

epidermal cells for reclustering analysis







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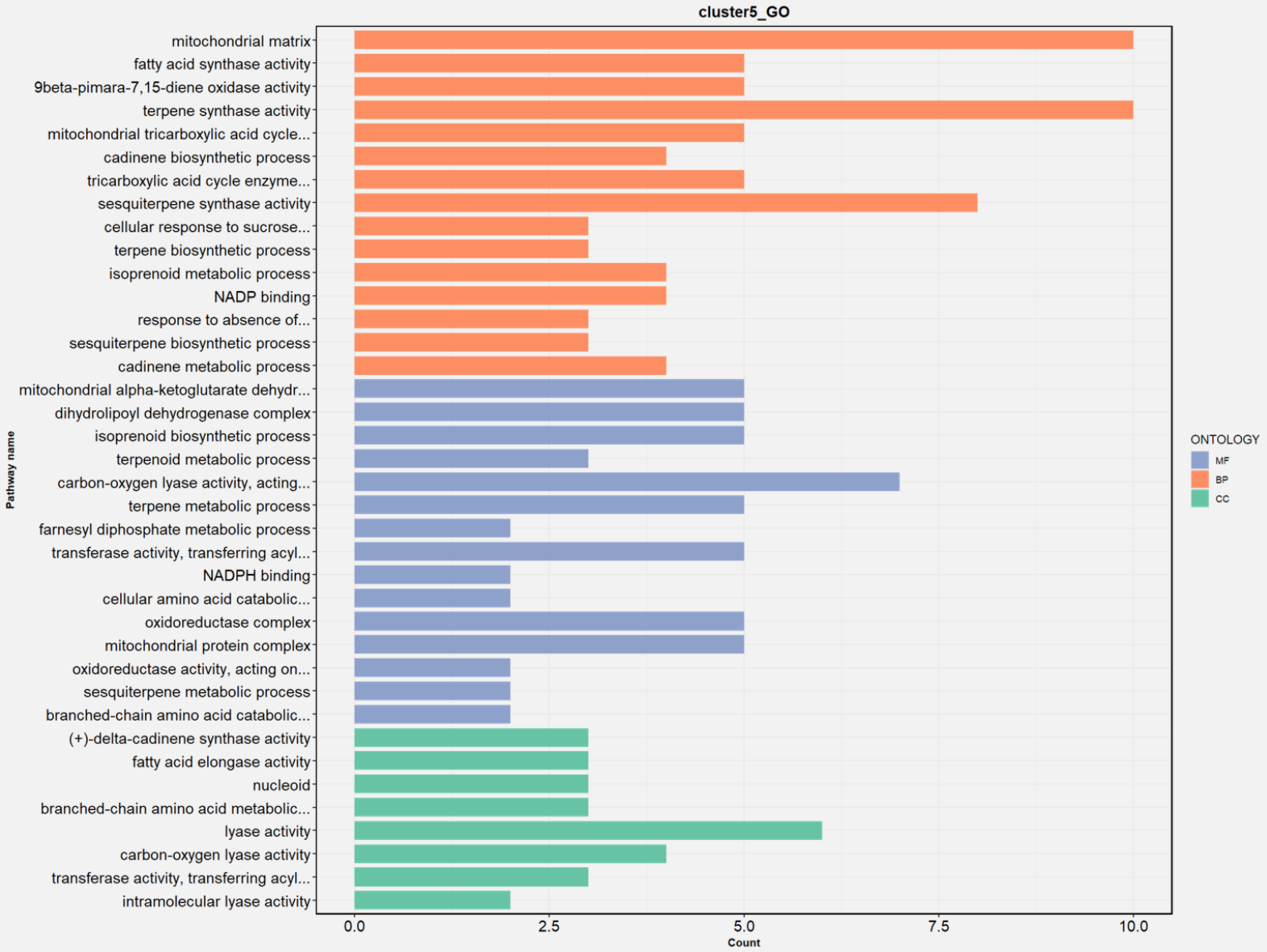
Reveal development of glandular trichomes by scRNA-seq

terpenoid metabolic process
isoprenoid metabolic process
isoprenoid biosynthetic process
terpene synthase activity
diterpenoid metabolic process
response to UV
response to UV-B
cellular response to extracellular stimulus
sesquiterpene biosynthetic process



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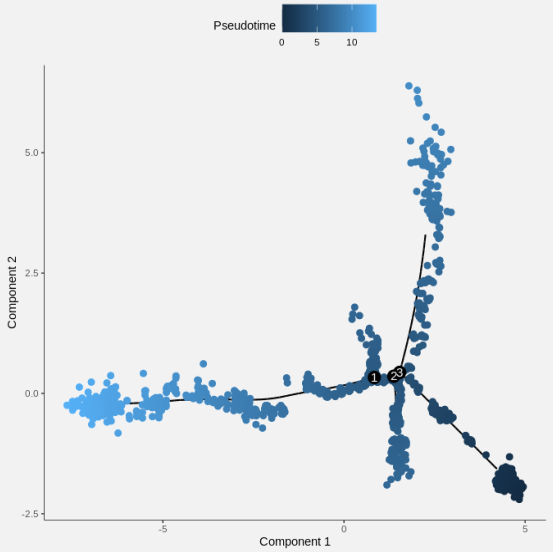

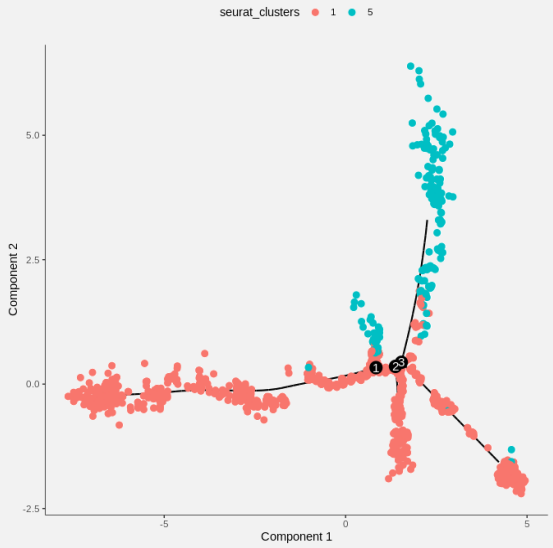

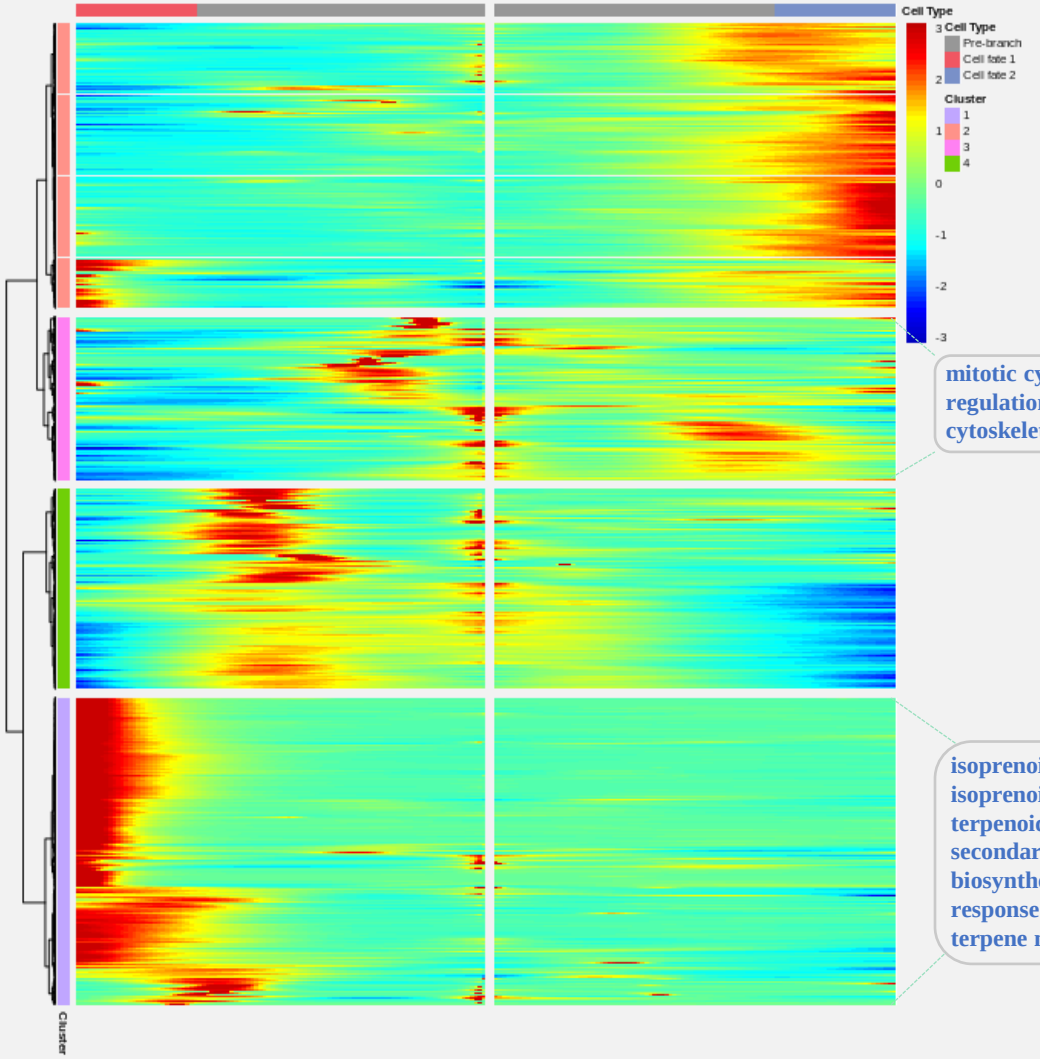

mitotic cytokinesis
regulation of growth
cytoskeletal protein binding

isoprenoid metabolic process
isoprenoid biosynthetic process
terpenoid metabolic process
secondary metabolite
biosynthetic process
response to UV
terpene metabolic process

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Reveal development of glandular trichomes by scRNA-seq

1. For glandular trichomes that are not easy to prepare protoplasts, if you want to apply single-cell omics, you can use nucleus extraction to replace the preparation of protoplasts.

2. Using the single-nucleus transcriptome technology, the single-nucleus atlas of tobacco leaves was reconstructed, and glandular trichomes were detected at the same time.

3. Using trajectory analysis, the developmental trajectory of glandular trichomes was reconstructed, and the genes controlling this process were obtained, but follow-up experimental verification is needed.

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