Table S4. Functional summary of TCP proteins in flower development

TCP subclass	Species	Genes	Biological function	References
PCF	*Arabidopsis thaliana*	*AtTCP15* (AT1G69690)	Regulating GA-dependent stamen filament elongation by directly activating SAUR63 subfamily genes	Gastaldi et al., 2020
		AtTCP16 (AT3G45150)	Expressing in pollen grain at the tetrad stage and involved in genomic DNA degeneration	Takeda et al., 2006
	Phalaenopsis equestris	*PePCF10* (KT258880)	Expressing in ovules at early stages by modulating cell division	Lin et al., 2016
CIN	*Antirrhinum majus*	*AmCIN* (AY205603)	Affecting epidermal cell differentiation and growth of petal lobes	Crawford et al., 2004
	Arabidopsis thaliana	*AtTCP4* (AT3G15030)	TCP4 expression compensates the green petal by repressing chlorophyll genes	Zheng et al., 2022
		AtTCP5 (AT5G60970)	Regulating the smoothness of the surface and margin of petals	Koyama et al., 2011
	Commelina communis	*CcTB1a* (JQ622131)	Stronger Expression in ventral versus dorsal tepals, and expressed in different directions in stamens asymmetrically	Preston & Hileman, 2012
	Commelina dianthifolia	*CdTB1a* (JQ622142)	Stronger Expression in ventral versus dorsal tepals, and parallel recruitment in the independent evolution	Preston & Hileman, 2012
	Erycina pusilla	*EPTCP11* (PP515908)	Highly expressed in the dorsal labellum, and changed the radially symmetric flower to a bilaterally symmetric flower	Tang et al., 2024
		EPTCP26 (PP515910)	Highly expressed in the dorsal labellum	Tang et al., 2024
	Ipomoea nil	*InTCP4* (EF216864)	Controlled by both light/clock and miR319, and regulating flower development	Glazińska et al., 2013
	Petrocosmea glabristoma	*PgCIN1* (KT596752)	Weak expression in all petals, contributing to shorter dorsal petals to ventral ones	Yang et al., 2015
	Petrocosmea sinensis	*PsCIN1* (KT596759)	Strong expression in all petals, contributing to equal length of dorsal and ventral petals	Yang et al., 2015
	Petunia hybrida	*PhLA*	Regulating flower morphogenesis, including petal curvature and epidermal cell differentiation	Chen et al., 2020
	Phalaenopsis equestris	*PeCIN8* (KT258889)	Expressing in ovules at late stages by modulating cell division	Lin et al., 2016
CYC	*Antirrhinum majus*	*AmDICH* (AF199465)	Expressing in the dorsal corolla, and regulating floral zygomorphy with *CYC* gene	Luo et al., 1996

	AmCYC (AY316729)	Repressing cell cycle genes such as CYCLIN D3b in the dorsal stamen	Gaudin et al., 2000
Arabidopsis thaliana	*AtTCP1* (AT1G67260)	Dorsal expression at stage 2 floral primordia but disappeared at stage 5, suppressing petal growth size	Cubas et al., 2001; Busch & Zachgo., 2007
Callicarpa cathayana	*CcCYC2A* (KM526842)	Strongly correlating with early radial corolla development.	Zhong et al., 2017
Chirita pumila	*CpCYC1*,*2* (OQ515463, (OQ515464)	Controlling floral symmetry, orientation and nectar guide pattering	Yang et al., 2023
Costus spicatus	*CsTBL1a* (HM775139)	Accumulating in the ventral petaloid staminode, petals and sepal	Bartlett & Specht, 2011
	CsTBL2 (HM775140)	Enriching in the dorsal fertile stamens	Bartlett & Specht, 2011
Eschscholzia californica	*EcCYLs*	Promoting stamen initiation and petal growth	Zhao et al., 2018
Heliconia stricta	*HsTBL1a* (HM775094)	Accumulating in the posterior(adaxial) staminode	Bartlett & Specht, 2011
	HsTBL2 (HM775126)	Strongest expression in the anterior (abaxial) sepals	Bartlett & Specht, 2011
Knautia macedonica	*KmCYC1* (KT965757)	Determining symmetry	Berger et al., 2016
	KmCYC3B (KT965762)	Asymmetric expression across dorsoventral axis	Berger et al., 2016
Lobelioideae	*CamCYC2A,2B*	Highly expressed in the ventral petal lobes, corresponding to the adaxial side relative to meristem orientation	
Lotus japonicus	*LjCYC1*,*2*,*3* (DQ202475, DQ202476, DQ202477)	Controlling zygomorphic flower development and causing DV asymmetry	Xu et al., 2013; Feng et al., 2006; Wang et al., 2008
Mentha longifolia	*MlCYC2A*,*2B* (KM526784, KM526785)	Altered expression of *CYC2B* and the loss of *CYC2A* are responsible for late radial symmetry	Zhong et al., 2017
Mimulus lewisii	*MlCYC2A*	This molecular tug-of-war between MlBOP and MlCYC2A regulates MlCYC2A expression, shaping bilateral floral symmetry.	Gao et al., 2024
Petrocosmea glabristoma	*PgCYC1C*,*1D* (KT596748, KT596749)	Strong expression in dorsal petals, contributing to shorter dorsal petals to ventral ones	Yang et al., 2012, Yang et al., 2015
Petrocosmea	*PsCYC1C*,*1D*	Weak expression in dorsal petals,	Yang et al.,

sinensis	(KT596755, KT596756)	contributing to equal length of dorsal and ventral petals	2012, Yang et al., 2015
Pisum sativum	*PsCYC2*,*3* (EU574914, EU574915)	Silencing showed partial to complete conversion of wings into keel shapes and displayed lobed or retarded standards	Wang et al., 2008
Primulina heterotricha	*PhCYC1C* (JX020500)	Reducing petal sizes by repressing cell expansion	Liu et al., 2013
Prunus mume	*PmCYLs*	Controlling the identity of flower types	Zhou et al., 2016
Torenia fournieri	*TfCYC1*,*2* (KY502188, KY502194)	CYC-RAD module coordinates petal shape and corolla pigmentation	Su et al., 2017
Tradescantia pallida	*TpTB1a* (JQ622132)	Expressed similarly in both the ventral and dorsal tepals and parallel recruitment in the independent evolution	Preston & Hileman, 2012
Saintpaulia ionantha	*SiCYC1A*,*B* (MG989467, MG989468)	Separately controlling two contrasting actinomorphic reversals	Hsu et al., 2018

References

Busch A, Zachgo S. 2007. Control of corolla monosymmetry in the Brassicaceae Iberis amara. *Proceedings of the National Academy of Sciences of the United States of America* **104**: 16714–16719.

Chen HW, Lee PL, Wang CN, Hsu HJ, Chen JC. 2020. Silencing of PhLA, a CIN-TCP gene, causes defected petal conical epidermal cell formation and results in reflexed corolla lobes in Petunia. *Botanical Studies* **61**(1):24.

Crawford BCW, Nath U, Carpenter R, Coen ES. 2004. Cincinnata controls both cell differentiation and growth in petal lobes and leaves of antirrhinum. *Plant Physiology* **135**: 244–253.

Cubas P, Coen E, Zapater JMM. 2001. Ancient asymmetries in the evolution of flowers. *Current Biology* **11**: 1050–1052.

Gastaldi V, Lucero LE, Ferrero LV, Ariel F D, Gonzalez DH. 2020. Class-I TCP transcription factors activate the SAUR63 gene Subfamily in gibberellin-dependent stamen filament elongation. *Plant Physiology* **182**(4):2096-2110.

Gaudin V, Lunness PA, Fobert PR, Towers M, Riou-Khamlichi C, Murray JAH, Coen E, Doonan JH. 2000. The expression of D-cyclin genes defines distinct developmental zones in snapdragon apical meristems and is locally regulated by the Cycloidea gene. *Plant Physiology* **122**: 1137–1148.

Glazińska P, Wilmowicz E, Wojciechowski W, Frankowski K, Kopcewicz J, et al. 2013. Impact of InMIR319 and light on the expression of InTCP4 gene involved in the development of Ipomoea nil plants. *Acta Physiologiae Plantarum* **36**(1):29-43.

Hsu HJ, He CW, Kuo WH, Hsin KT, Lu JY, et al. 2018. Genetic analysis of floral symmetry transition in African Violet suggests the involvement of trans-acting factor for CYCLOIDEA expression shifts. *Frontiers in Plant Science* **9**:1008.

Koyama T, Sato F, Ohme-Takagi M. 2011. A role of TCP1 in the longitudinal elongation of leaves in *Arabidopsis*. *Biosci Biotechnol Biochem* **74**(10):2145-2147.

Preston JC, Hileman LC. 2012. Parallel evolution of TCP and B-class genes in Commelinaceae flower bilateral symmetry. *EvoDevo* **3**: 1–14.

Lin YF, Chen YY, Hsiao YY, Shen CY, Hsu JL, et al. 2016. Genome-wide identification and characterization of TCP genes involved in ovule development of *Phalaenopsis equestris*. *Journal of Experimental Botany* 67(17):5051-5066.

Liu BL, Pang HB, Yang X, Wang YZ. 2013. Functional and evolutionary analyses of *Primulina heterotricha* CYC1C gene in tobacoo and Arabidopsis transformation systems. *Journal of Systematics and Evolution* **52**(1):112-123.

Luo D, Copsey L, Vincent C, Copsey L, Coen E. 1996. Origin of floral asymmetry in Antirrhinum. *Nature* **383**:794-9.

Su SH, Xiao W, Guo WX, Yao XR, Xiao JQ, et al. 2017. The CYCLOIDEA–RADIALIS module regulates petal shape and pigmentation, leading to bilateral corolla symmetry in Torenia fournieri (Linderniaceae). *New Phytologist* **215**(4):1582-1593.

Takeda T, Amano K, Ohto MA, Nakamura K, Sato S, et al. 2006. RNA Interference of the Arabidopsis Putative Transcription Factor TCP16 Gene Results in Abortion of Early Pollen Development. *Plant Molecular Biology* **61**(1-2):165-177.

Tang Y, Zhong Y, Huang X. 2024. Identification and Functional Analysis of the Flower Development-Related TCP Genes in Erycina pusilla. *Horticulturae* **57**: 534.

Wang Z, Luo Y, Li X, Wang L, Xu S, Yang J, Weng L, Sato S, Tabata S, Ambrose M, et al. 2008. Genetic control of floral zygomorphy in pea (Pisum sativum L.). *Proceedings of the National Academy of Sciences of the United States of America* **105**: 10414–10419.

Yang X, Pang HB, Liu BL, Qiu ZJ, Gao Q, Wei L, Dong Y, Wang YZ. 2012. Evolution of double positive autoregulatory feedback loops in CYCLOIDEA2 clade genes is associated with the origin of floral zygomorphy. *Plant Cell* **24**: 1834–1847.

Yang X, Zhao XG, Li CQ, Liu J, Qiu ZJ, et al. 2015. Distinct regulatory changes underlying differential expression of TCP genes associated with petal variations in zygomorphic flowers of Petrocosmea (Gesneriaceae). *Annals of Botany* **169**(3):2138-2151.

Zheng X, Lan J, Yu H, Zhang J, Zhang Y, Qin Y, Su XD, Qin G. 2022. Arabidopsis transcription factor TCP4 represses chlorophyll biosynthesis to prevent petal greening. *Plant Communications* **3**: 100309.

Zhong JS, Preston JC, Hileman LC, Kellogg EA, et al. 2017. Repeated and diverse losses of corolla bilateral symmetry in the Lamiaceae. *Annals of Botany* **119**(7):1211-1223.

Zhou YZ, Xu ZD, Zhao K, Yang WR, Cheng TR, et al. 2016. Genome-Wide identification, characterization and expression analysis of the TCP gene family in Prunus mume. *Frontiers in Plant Science* **7**:1301.