FIGURES

Figure 1. The larval and adult mushroom bodies.

(A) Third instar larval brain stained with anti-FAS II (magenta) and GFP (green) driven by a MB *GAL4* line, 201Y. (B) Adult brain stained for FAS II (magenta) and *dnc-lacZ* (green). DL, dorsal lobe; ML, medial lobe; Ped, peduncle; cx, calyx; OL, optic lobe; α and α', adult dorsal lobes; β, β' and γ, adult medial lobes. Reconstruction of optical sections. Scale bars, 50 μm.

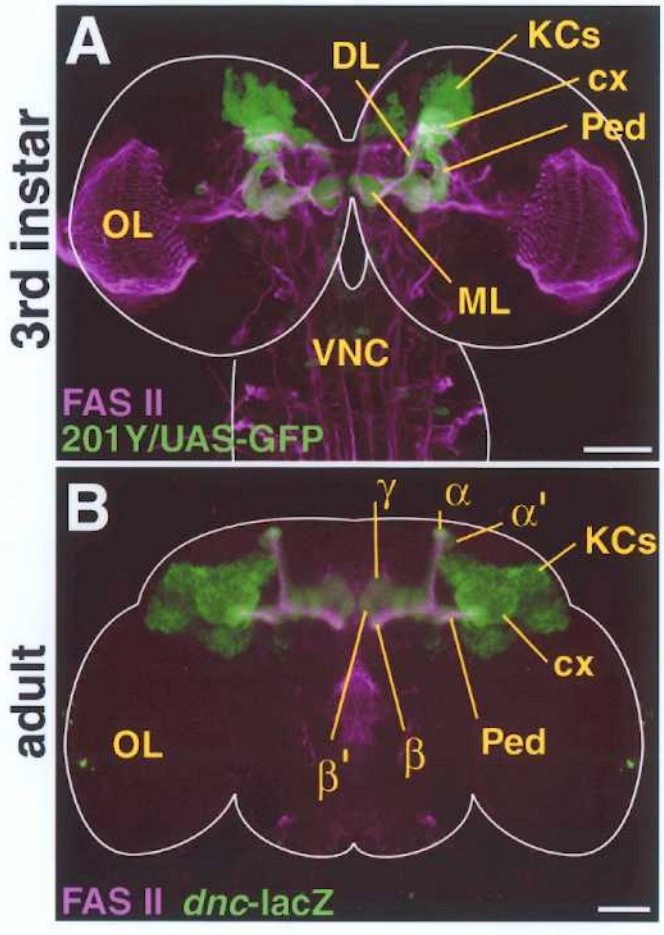

A
3rd instar
DL
KCs
cx
Ped
OL
ML
VNC
FAS II
201Y/UAS-GFP
B
adult
γ
α
α'
KCs
cx
OL
β'
β
Ped
FAS II dnc-lacZ

Figure 2. Development of the mushroom bodies.

(A) Embryonic MB primordium. Lateral image of embryonic brain hemisphere at stage 17 showing the four MB neuroblasts (MB-Nbs) that locate at the anterior end (in neuraxis) of the brain and give rise to the embryonic Kenyon cells (KCs). Axonal tracts of the peduncle and two orthogonal lobes are pioneered by this stage. (B) Third instar larval MB. The larval MB structure is basically an extension of the embryonic one with increasing number of Kenyon cells (KCs) and their axons. The peduncle (ped) split into the dorsal (DL) and medial (ML) lobes. cx, calyx. (C) Late pupal and adult MBs. After massive reorganization during the first half of the pupal stage, two dorsal (α and α') and three medial lobes (β, β' and γ) are formed. Together with heel (h), these adult type structures can be classified into three axonal projection groups (α/β, α'/β' and γ/heel), which are indicated with different shadings in the figure. Scale bars, A: 10 μm; B: 50 μm; C: 60 μm.

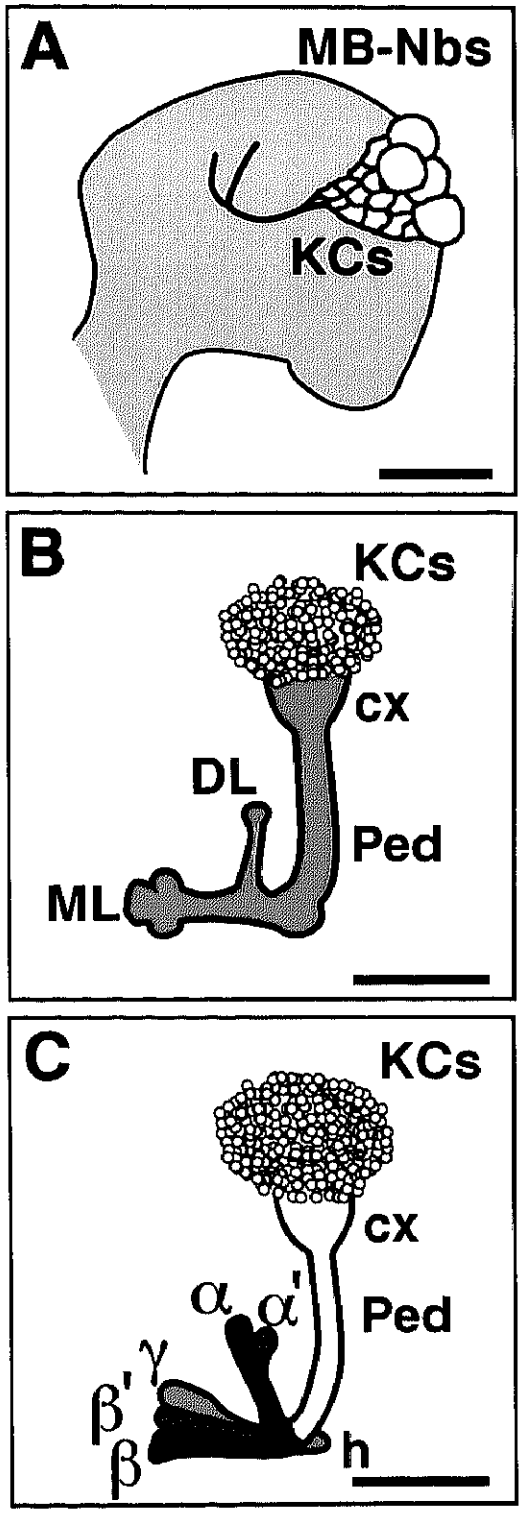

A
MB-Nbs
KCs
B
KCs
cx
DL
Ped
ML
C
KCs
cx
α
α'
Ped
γ
β'
β
h

Figure 3. Embryonic development of the MB axonal tracts

(A-C) Single optical sections showing the embryonic MB tracts. Lateral views. Scale bar, 10 μm. The embryonic MB tracts are labeled with *UAS-tau-lacZ* (green) driven by 238Y-*GAL4*. The major brain tracts are visualized with anti-FAS II antibody (magenta). (A) Stage 14. Arrowheads indicate an interface cell that co-expresses FAS II and 238Y on its surface. MB neuroblasts are indicated with stars. (B) Stage 15. The 238Y MB neurons extend thin pioneer axons (arrows) along the FAS II expressing cells. (C) Stage 16. The MB tracts converge at LPT. FAS II expression on the nearby cells is down regulated by this stage while the growing MB tracts (arrows) become more prominent. (D, E) Late stage 16. Reconstructed from optical sections. Lateral (D) and dorsal (E) views. The 238Y signal (green) is selectively enhanced to show the embryonic MBs. Major FAS II tracts also are shown (white). The embryonic brain hemisphere and its core neuropil are outlined with brown line. iACT, inner antennocerebral tract; BN, Bolwig's nerve; DCT, dorsal commissural tract; fc, frontal commissure; LPT, lateral protocerebral tract; MPT, medial protocerebral tract; OL, optic lobe; Ped, peduncle; VCT, ventral commissural tract. P1, P4l, P4m, P5l, fiber tract founder clusters (Nassif et al., 1998). Scale bars, 10 μm.

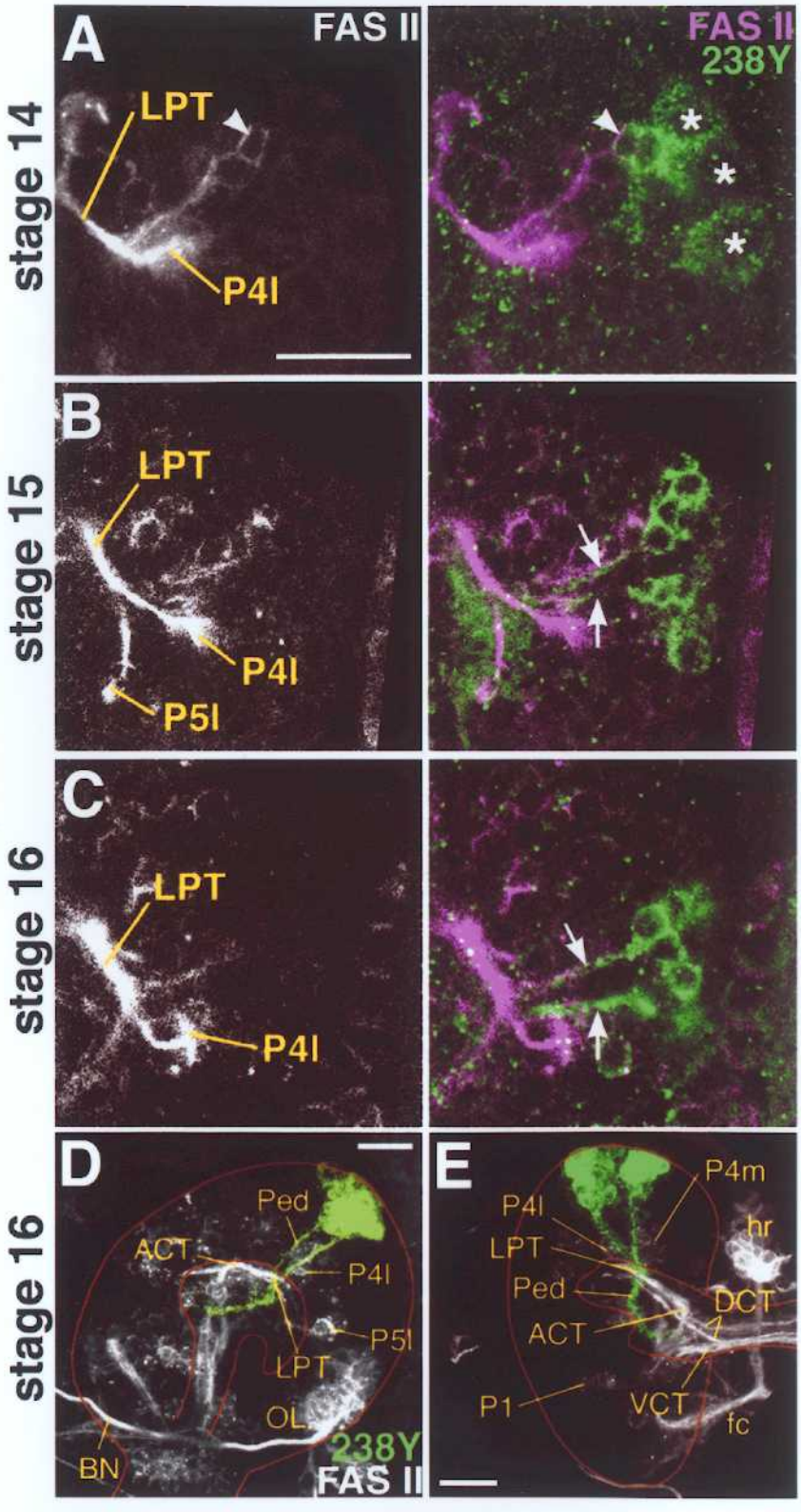

A
FAS II
LPT
P4l
FAS II
238Y
stage 14
B
LPT
P4l
P5l
stage 15
C
LPT
P4l
stage 16
D
Ped
ACT
P4l
P5l
LPT
OL
BN
238Y
FAS II
stage 16
E
P4m
P4l
hr
LPT
Ped
DCT
ACT
P1
VCT
fc

Figure 4. Schematic presentation of the MB primordia in the embryonic brain.

Dorsal view of the embryonic brain at late stage 16. ACT, antennocerebral tract; DCT, dorsal commissural tract; KCs, Kenyon cells; LPT, lateral protocerebral tract; MPT, medial protocerebral tract; Ped, peduncle; VCT, ventral commissural tract. P1, P4l, P4m, and D/T, fiber tract founder clusters (according to Nassif et al., 1998). Only major tracts are shown. Optic lobes are not included.

Embryonic Brain

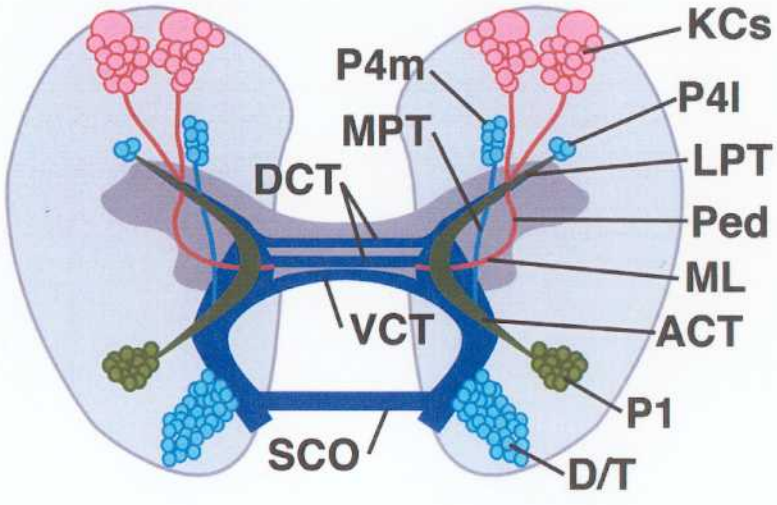


Figure 5. EY expression in the embryonic brain.

(A, B) Single optical sections showing the expression of an embryonic MB marker, 238Y(blue), and EY (red) in the embryonic brain. Brain is visualized with neuron-specific anti-HRP antibody (green). (A) Dorsal view of whole brain at stage 16 and (B) higher magnification of lateral view of the MB primordium at stage 15. In (B), note coexpression (pink/violet) of EY and 238Y. The 238Y signal is particularly strong in two of the MB neuroblasts and their progenies. Arrows, MB primordia. Stars, MB neuroblasts. (C) Reconstruction of optical sections of embryonic brain at late stage 14 double labeled with anti-EY (red) and anti-FAS II (white) antibodies. The EY is expressed in several discrete cell clusters including those of the MB primordia and the deutocerebrum anlagen (arrow). Prominent FAS II tracts, which gives rise to the antennocerebral tract (ACT), connects the two brain centers. BN, Bolwig's nerve; DCT, dorsal commissural tract; fc, frontal commissure; LPT, lateral protocerebral tract; MPT, medial protocerebral tract; OL, optic lobe; Ped, peduncle; VCT, ventral commissural tract. P1, P4l, P4m, P5l, D/T fiber tract founder clusters. Scale bars, A and C: 10 μm; B: 25 μm.

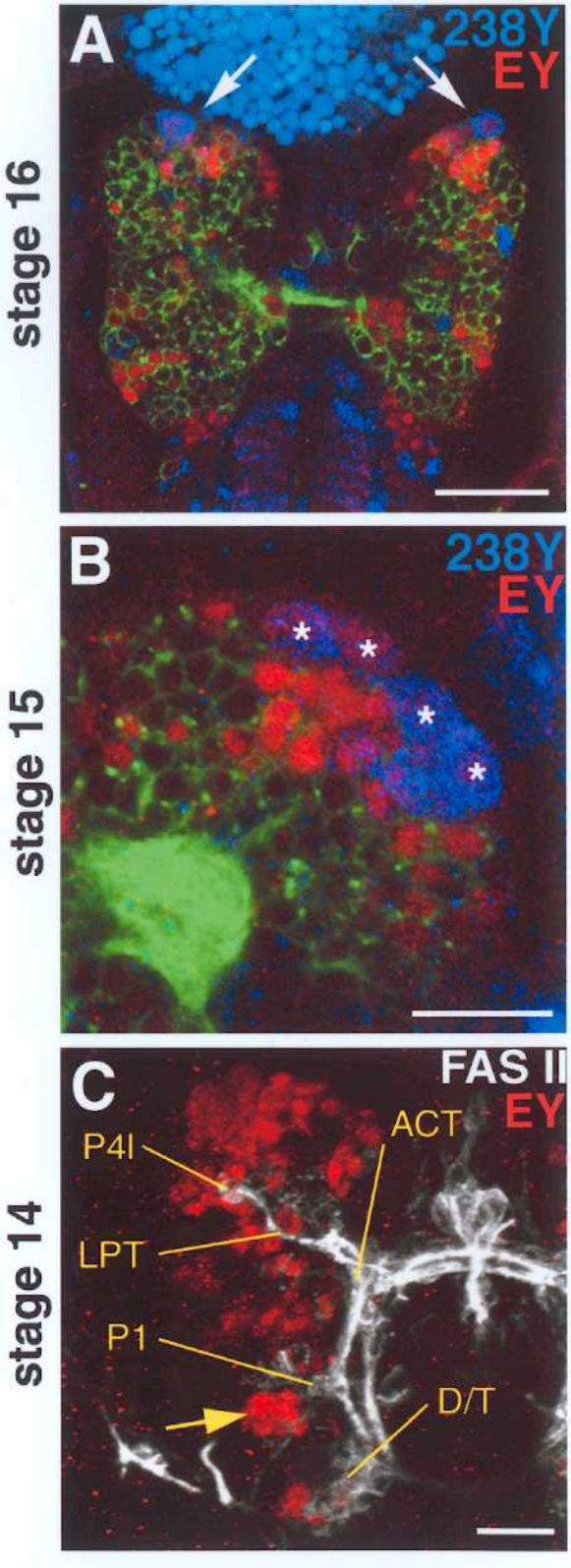

A
238Y
EY
stage 16
B
238Y
EY
stage 15
C
FAS II
EY
ACT
P4l
LPT
P1
D/T
stage 14

Figure 6. Expression of nuclear regulatory genes in the embryonic mushroom body primordia.

Single optical sections of embryonic brains at stage 15. Brain is visualized with neuron-specific anti-HRP antibody (green). (A) Expression of *toy* transcripts (yellow) in the embryonic MB. Fluorescent in situ hybridization. Lateral view of the MB primordium at higher magnification. Stars, MB neuroblasts. Bar, 25μm. (B) Expression of EY (blue) and DAC (red) in the embryonic brain. Note the coexpression (pink/violet) of EY and DAC in the MB primordia (arrows). Bar, 10μm. (C) Expression of *so* transcripts (yellow) in the embryonic MB. Fluorescent in situ hybridization. Lateral view of the MB primordium at higher magnification. Stars, MB neuroblasts. (D) Expression of EYA (red) and 238Y (blue) in the embryonic brain. EYA is expressed in nearby cells but not in the MB primordia (arrows).

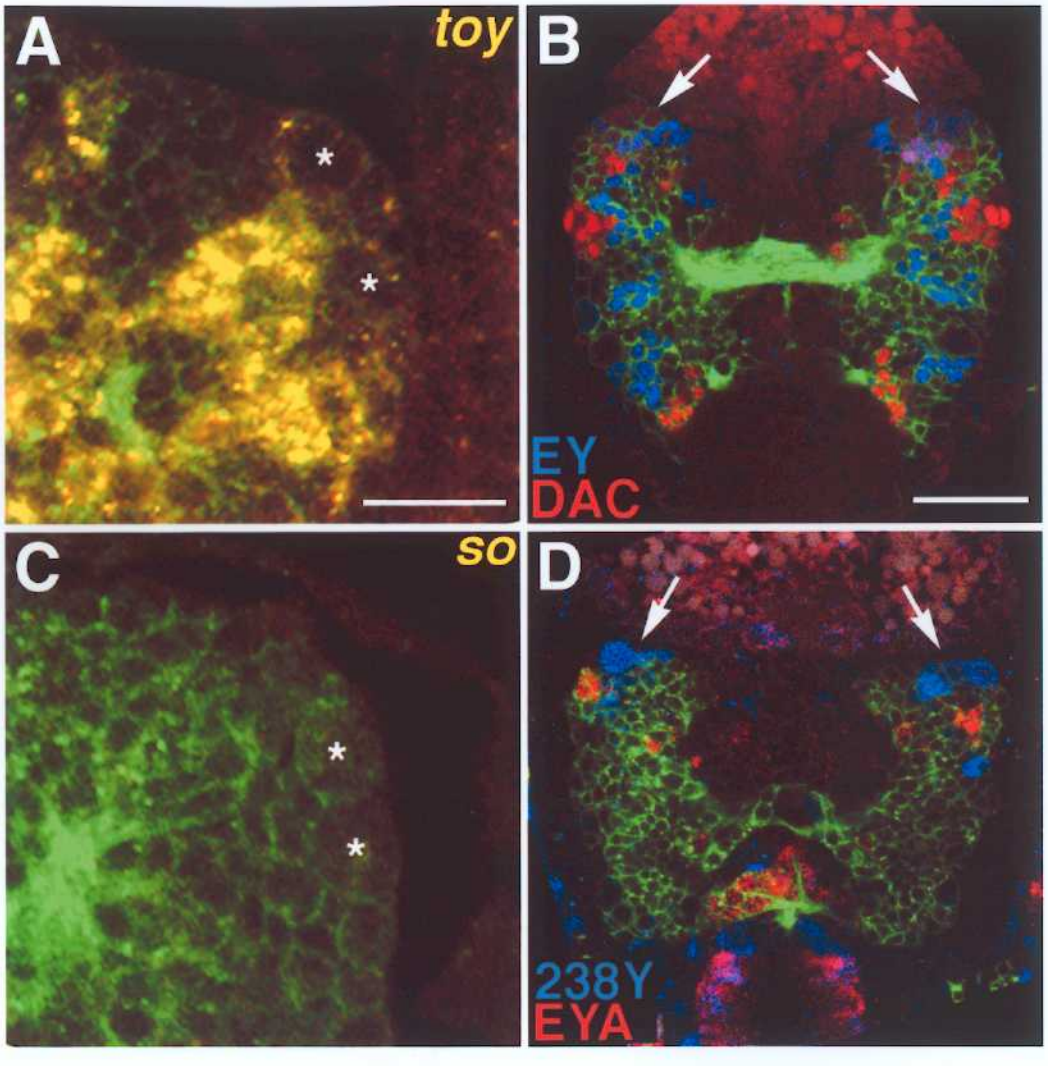
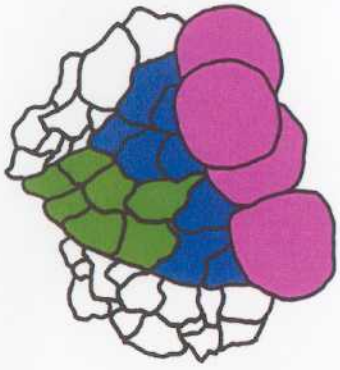

A
toy
B
EY
DAC
C
so
D
238Y
EYA

Figure 7. Summary of the expression pattern of *Pax6* and other regulatory genes in the embryonic MBs.

Lateral image of embryonic MB primodium. Expression patterns of various regulatory genes are summarized in the table. Nbs, neuroblasts; GMCs, ganglion mother cells; KCs, Kenyon cells.



	ey	*toy*	*dac*	*eya*	*so*
MB-Nb	++	+	+	-	-
GMC	++	++	++	-	-
Kenyon Cell	++	++	++	-	-

Figure 8. Expression of nuclear regulatory genes in the larval MBs.

Laser confocal microscopy of third instar larval brains. Reconstruction of optical sections (A) and single optical sections (B-H). (A) Larval MB labelled for a *Gal 4* MB marker (201Y, green), and EY (magenta). Lateral view showing the Kenyon cells (KCs), calyx (cx), peduncle (Ped), and the larval lobes (DL and ML). Note prominent coexpression (white) of EY and 201Y in Kenyon cells that locate above calyx. Bar, 50 μm. (B, C) Expression of EY (magenta/white) and 201Y (green/white) in larval Kenyon cells. Dorsal views. (B) EY expression, (C) same as B but shows both EY and 201Y. Star, MB neuroblasts. Bar, 40 μm. (D) Expression of *toy* (green) in Kenyon cells. Fluorescent *in situ* hybridization. Dorsal view. Identical pattern was confirmed with anti-TOY antibody (U. W. unpublished). (E, F) Differential expression of EY (green/white) and DAC (magenta/white) in the larval Kenyon cells around the four MB neuroblasts (stars). (E) EY expression, (F) same as E but shows both EY and DAC. (G) Expression of EY (green) and *so-lacZ* (magenta) in larval brain. Similar result was obtained by *in situ* hybridization for *so* transcripts. (H) Expression of EYA (magenta) and 201 (green) in larval brain. Arrows, EYA positive cells.

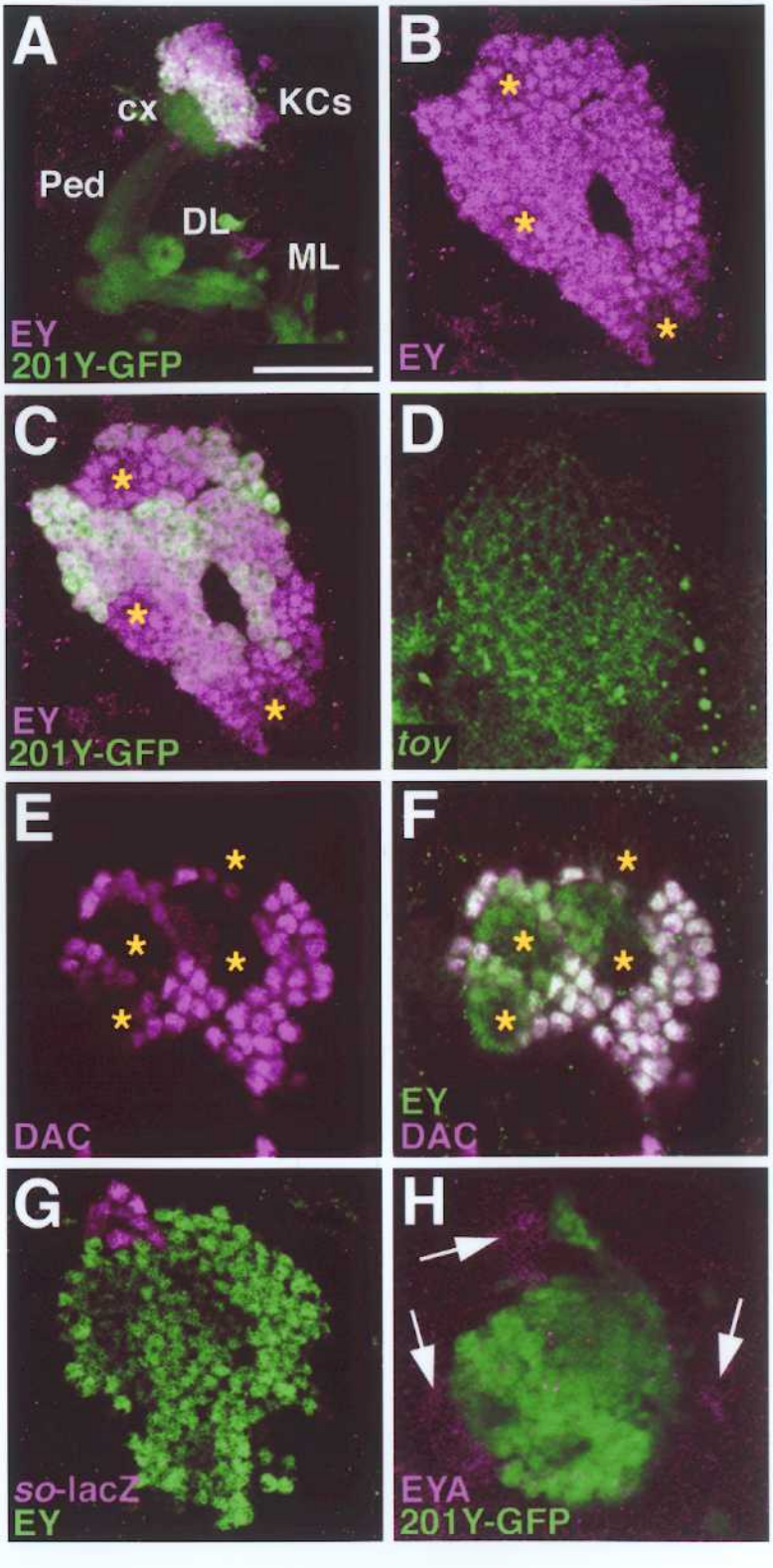
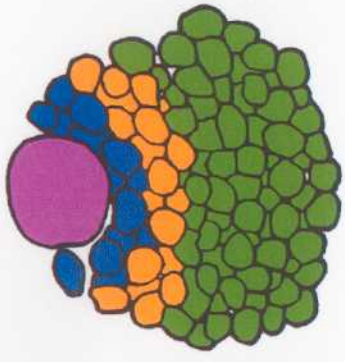

A
cx
KCs
Ped
DL
ML
EY
201Y-GFP
B
EY
C
EY
201Y-GFP
D
toy
E
DAC
F
EY
DAC
G
so-lacZ
EY
H
EYA
201Y-GFP

Figure 9. Summary of the expression pattern of *Pax6* and other regulatory genes in the larval MBs.

Dorsal image of Kenyon cell clusters in late third instar larval MB. Expression patterns of various regulatory genes are summarized in the table. Nbs, neuroblasts; GMCs, ganglion mother cells; KCs, Kenyon cells.



	ey	*toy*	*dac*	*eya*	*so*	201Y-Gal4
NBs	+	+	-	-	-	-
GMCs	++	++	±	-	-	-
Inner KCs	++	++	++	-	-	-
Outer KCs	++	++	++	-	-	++

Figure 10. Structural defects of larval MBs.

Reconstruction of optical sections of larval brains labelled with anti-FAS II (red) and anti-DIF (blue). (A-D) Larval MBs at the third instar stage. (A) Wild-type MB showing peduncle (Ped) and lobes (DL and ML). (B) MB in *ey* mutant. Note reduced and irregular FAS II expression whereas DIF staining supports structural retention of the lobes and peduncle. FAS II is lost from the globular end of the DL (arrowhead). (C) MB in *dac* mutant. Wild type like MB with homogeneous and concentric FAS II and DIF staining. (D) MB in *ey* mutant heterozygous for *dac*. Note enhanced irregularity in FAS II expression and structural degeneration of the DL (arrowhead). Scale bar, 50 μm.

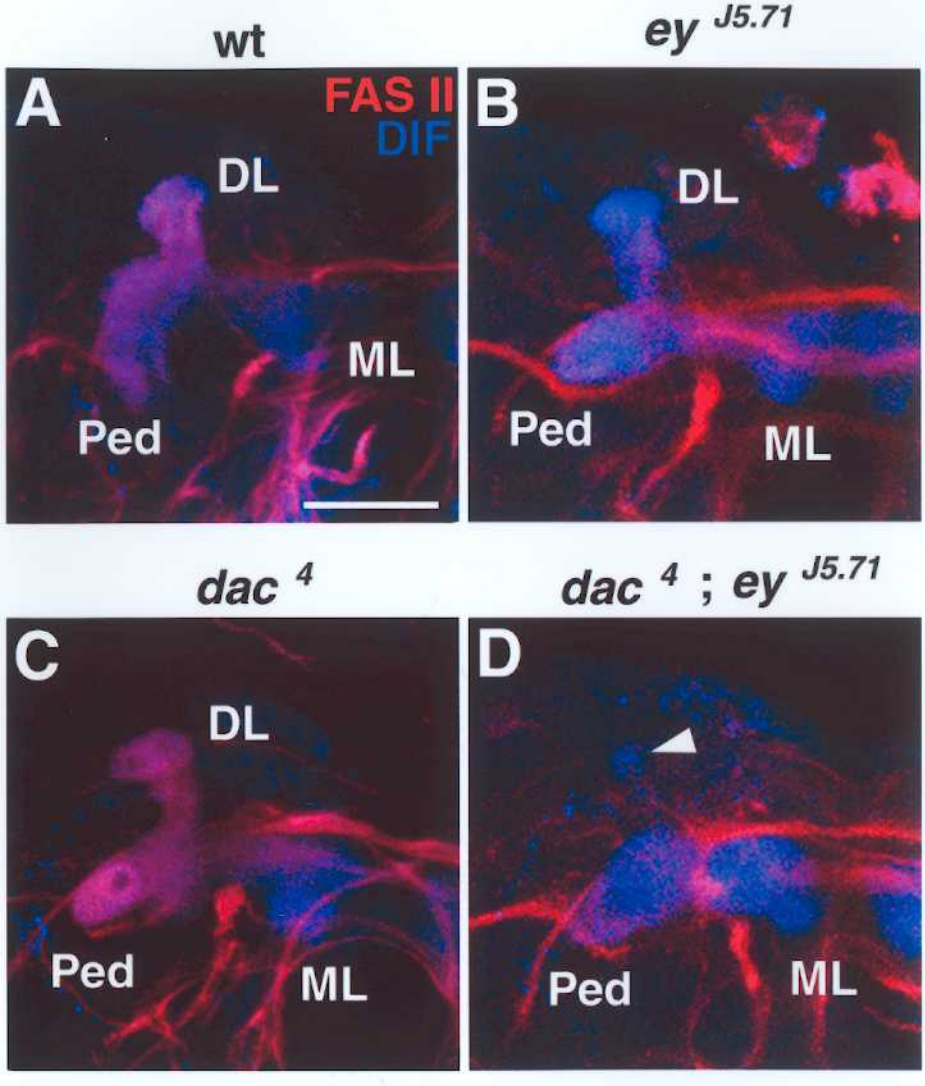

wt
ey J5.71
A
FAS II
DIF
DL
ML
Ped
B
DL
Ped
ML
dac 4
dac 4 ; ey J5.71
C
DL
Ped
ML
D
Ped
ML

Figure 11. Structural defects of pupa MBs.

Reconstruction of optical sections of pupal brains labelled with anti-FAS II (red) and anti-DIF (blue). (A) Wild-type MBs showing strong FAS II expression in the α and β lobes and DIF expression in the γ lobe. Both FASII and DIF are moderately expressed in the peduncles and the other lobes. eb, ellipsoid body. (B) MBs in *ey* mutant. All the MB structures are abolished except for Kenyon cells, which retain DAC expression (red). (C) MBs in *dac* mutant. Note the significant malformation in the FAS II tracts. The lobes and peduncles are structurally irregular as revealed by weak DIF staining. Arrowheads, abnormal medial lobes. Kenyon cells expressing EY (blue) are retained. (D) MBs in *dac* mutant. Moderate case retaining larval-like architecture. Arrowheads indicate aberrant branching of ectopic peduncles. Stars in B-D indicate central complex remnants. Scale bar, 50 μm.

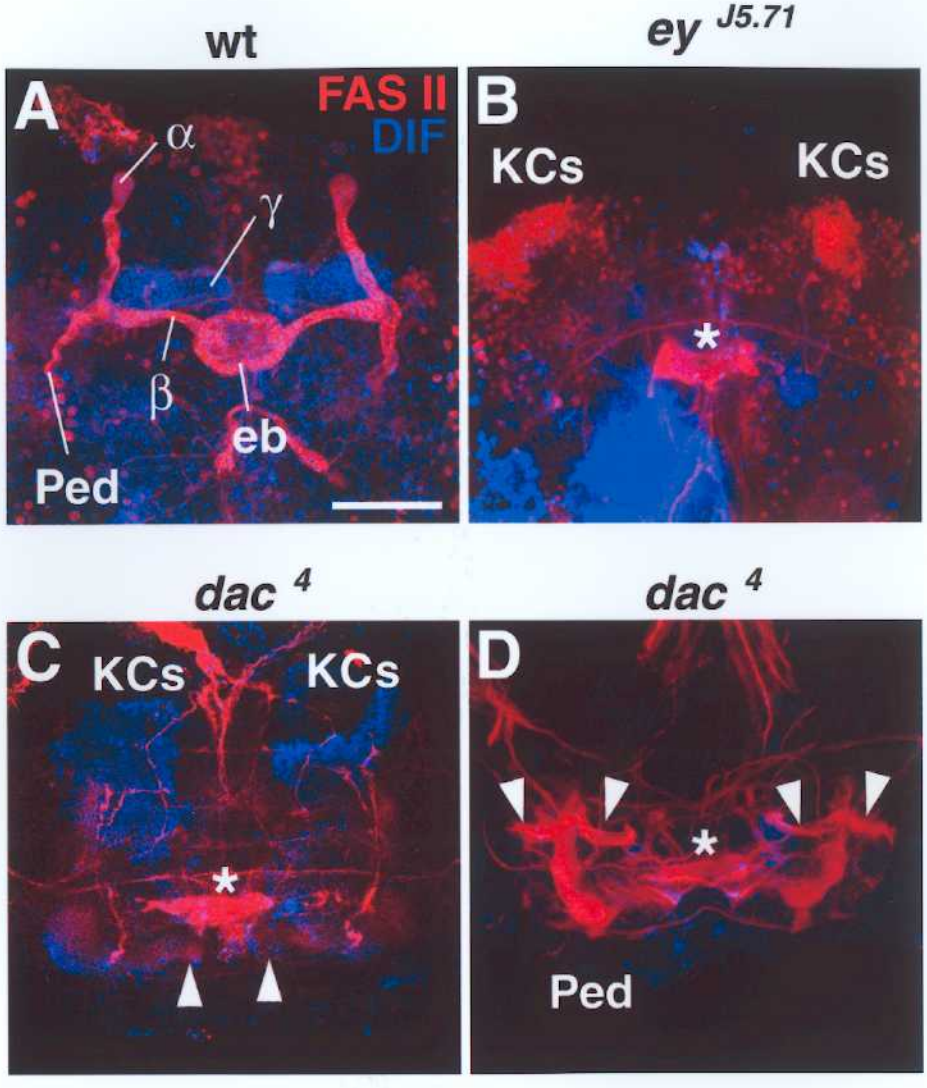

wt
ey J5.71
A
FAS II
DIF
α
γ
β
eb
Ped
B
KCs
KCs
*
dac 4
dac 4
C
KCs
KCs
*
D
*
Ped

Figure 12. Expression of EY and DAC in mutant backgrounds.

(A-C) Single optical sections showing the expression of EY (blue) and DAC (red) in embryonic MBs, lateral views. Brain is visualized with neuron-specific anti-HRP antibody (green). Stars, MB neuroblasts. (A) wild-type brain at stage 14. Note clear coexpression (pink) of EY and DAC in embryonic Kenyon cells. (B) DAC (red) expression in *ey* mutant at stage 15. (C) EY (blue) expression in *dac* mutant at stage 15. (D-F) Single optical sections showing the expression of DAC (magenta) and EY (green) in third instar larval Kenyon cells. (D) Wild type. Note clear coexpression (white) of EY and DAC in embryonic Kenyon cells. (E) DAC expression in *ey* mutant. (F) EY expression in *dac* mutant. (G-I) Single optical sections showing the expression of DAC (magenta) and EY (green) in pupal Kenyon cells. 50 hours after puparium formation. (G) Wild type. DAC is coexpressed with EY in most Kenyon cells except for the central cells. (H) DAC expression in *ey* mutant. (I) EY expression in *dac* mutant. Scale bars, A: 10 μm; D, G: 25 μm.

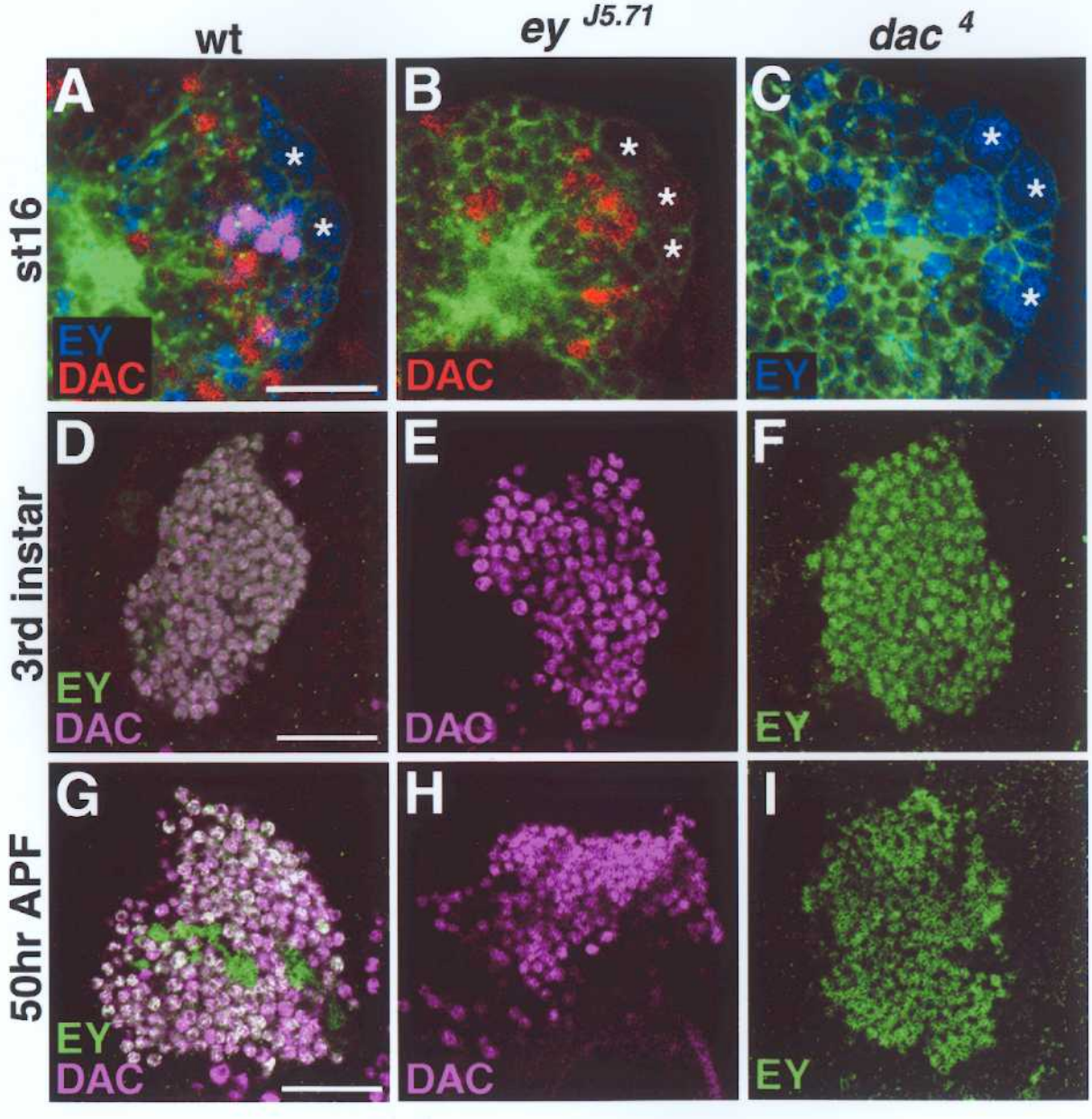

wt
ey J5.71
dac 4
st16
3rd instar
50hr APF
A
B
C
D
E
F
G
H
I
EY
DAC

Figure 13. Expression of TLL and DAC in nullo 4 embryo.

(A-C) Single optical sections showing the expression of TLL (blue) and DAC (red) in embryonic MBs, dorsal views. Brain is visualized with neuron-specific anti-HRP antibody (green). (A) wild-type brain at stage 15. Note the coexpression (pink/violet) of TLL and DAC in the MB primordia (arrows). TLL is expressed at high levels in the neuroblasts and GMCs of the MB primordia with minimum overlap with DAC. Bar, 25 μm. (B) *nullo4* embryo corresponding to stage 16. Neuroblasts expressing TLL are retained at lateral positions (arrowheads). The progenies of these neuroblasts express DAC. (C) Higher magnification of the white box region in (B). Stars, MB neuroblasts.

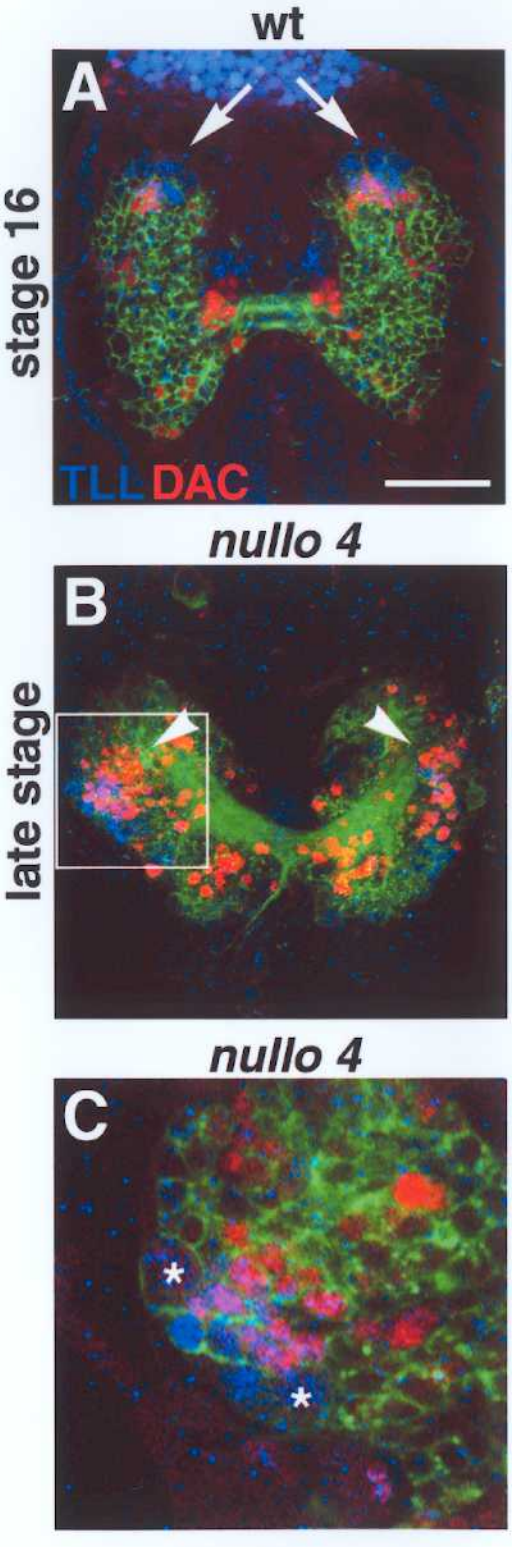
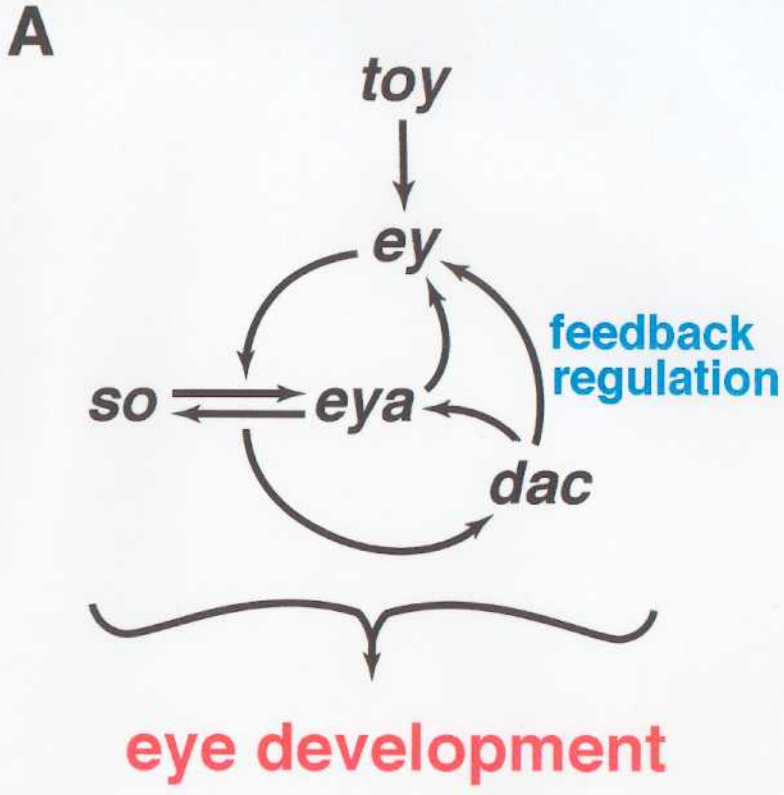

wt
A
stage 16
TLL DAC
nullo 4
B
late stage
nullo 4
C
*
*

Figure 14. Comparison of genetic networks in MB and Eye development.

(A) In eye development, the network of regulatory genes is established in a biphasic manner. A linear pathway is responsible for initiating expression of *ey*, *so*, *eya* and *dac* in the developing eye disc, while feedback control contributes to their regulation during larval development. (B) In MB development, three of the eye development genes, *ey*, *toy*, and *dac*, are expressed in the developing MBs and *ey* and *dac* have pivotal functions in the structural formation of the MBs. However, in contrast to the regulatory cascade in eye development, two of the key regulators, *so* and *eya*, are not expressed in the developing MBs. Furthermore, *ey* and *dac* are independently regulated in the MBs.


A
toy
ey
feedback
regulation
so
eya
dac
eye development

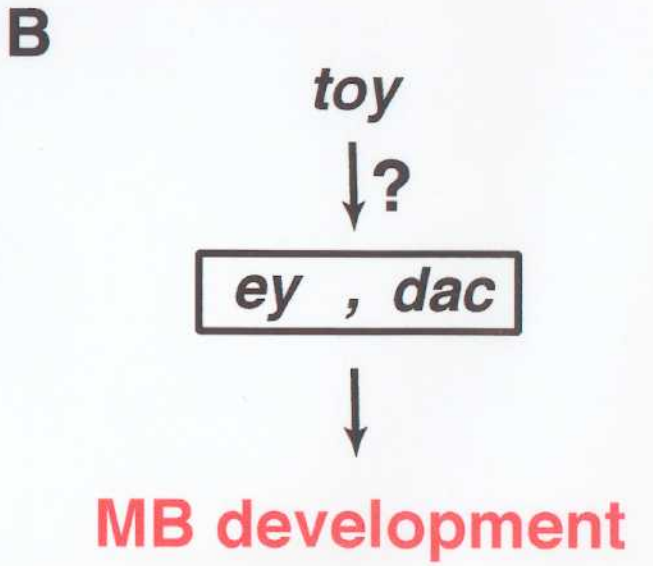

B
toy
?
ey , dac
MB development

Figure 15. Differential expression of MB markers in the first instar brain.

(A, D, G, J) Expression of *dnc-lacZ* is revealed by an anti-β-GAL antibody (green/white). (B, E, H, K) GFP expression driven by 201Y (green/white). (C, F, I, L) GFP expression driven by c739 (green/white). (A-C) Slightly oblique dorsal views of MBs showing the Kenyon cells labeled with an anti-DAC antibody (magenta/white). Stars indicate the positions of the MB neuroblasts. (D-F) Lateral views showing the peduncle and lobes. Major axonal tracts, lobes and peduncle are labeled with an anti-FAS II antibody (magenta/white). Note that FAS II is expressed in the lobes and the distal part of the peduncle. (G-I) Single optical sections of the medial lobes. Marker expression is shown on the right in single channel. (J-L) Single optical sections of the dorsal lobes. Marker and FAS II expressions are shown on the right in single channels. Similar internal staining was obtained for peduncle sections (not shown). Scale bars, A and D: 20 μm. cx, calyx; DL, dorsal lobe; h, heel; ML, medial lobe; Ped, peduncle; ACT, antennocerebral tract.

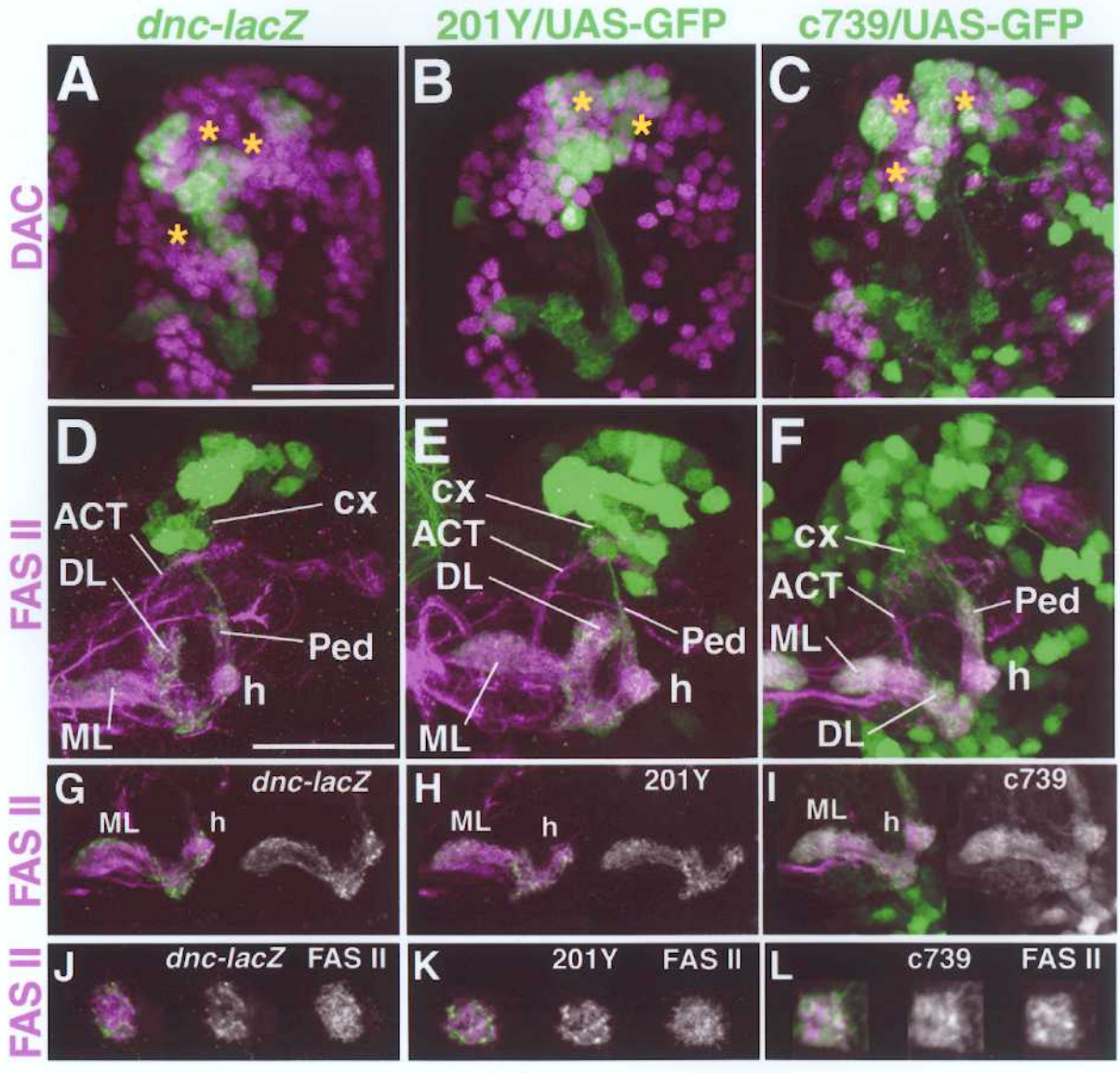

dnc-lacZ
201Y/UAS-GFP
c739/UAS-GFP
DAC
FAS II
A
B
C
D
E
F
ACT
cx
DL
Ped
h
ML
G
H
I
dnc-lacZ
201Y
c739
J
K
L
FAS II

Figure 16. Differential expression of MB markers in the second instar brain.

(A, D, G, J) Expression of *dnc-lacZ* (green/white). (B, E, H, K) GFP expression driven by 201Y (green/white). (C, F, I, L) GFP expression driven by c739 (green/white). (A-C) Dorsal views of the Kenyon cell clusters labeled with an anti-DAC antibody (magenta/white). Stars indicate the positions of the MB neuroblasts. (D-F) Lateral views. The peduncles and lobes are labeled with an anti-FAS II antibody (magenta/white). (G-I) Single optical sections of the peduncles and the medial lobes. Marker expression is shown on the right in single channel. (J-L) Single optical sections of the dorsal lobes. Marker and FAS II expressions are shown on the right in single channels. Note similar internal staining for the peduncles and the lobes. Scale bars, A and D: 25 μm. Abbreviations are the same as in Fig. 15.

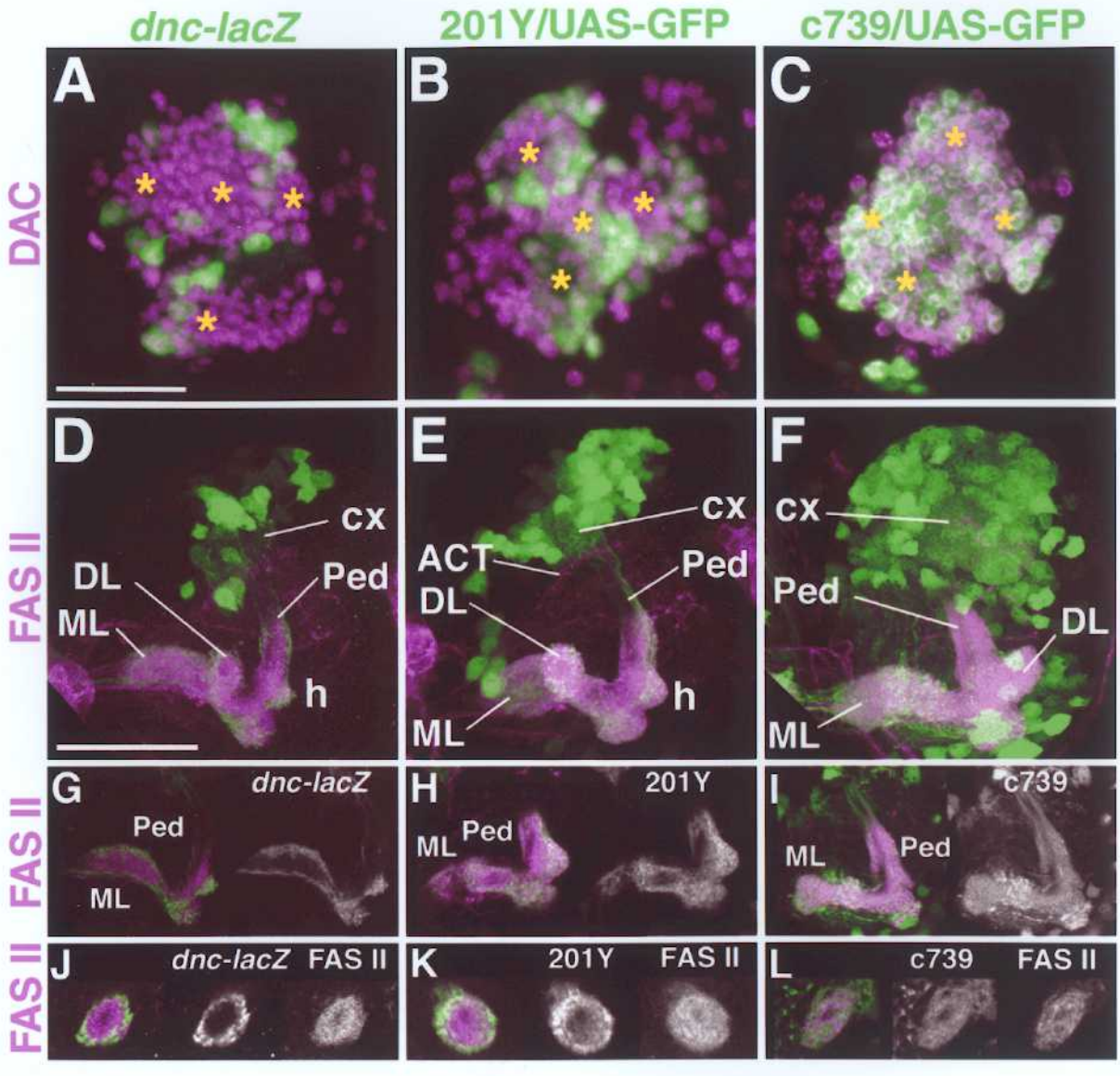

dnc-lacZ
201Y/UAS-GFP
c739/UAS-GFP
DAC
FAS II
A
B
C
D
E
F
cx
DL
ML
Ped
h
ACT
G
H
I
dnc-lacZ
201Y
c739
J
K
L
FAS II

Figure 17. Differential expression of MB markers in the third instar brain.

(A, D, G) Expression of *dnc-lacZ* (green/white). (B, E, H) GFP expression driven by 201Y (green/white). (C, F, I) GFP expression driven by c739 (green/white). (A-C) Dorsal views of the Kenyon cell clusters of wandering third-instar larvae labeled with an anti-DAC antibody (magenta/white). Single optical sections. Stars indicate the positions of the MB neuroblasts. (D-F) Lateral views showing the lobes and the distal part of the peduncles. Reconstruction of optical sections. (G-I) Single optical sections of the peduncles. The lobes and the peduncle are labeled with an anti-FAS II antibody (magenta/white). Note similar internal staining for the peduncles and the lobes. Expression of 201Y and c739 was monitored with *UAS-GFP*. FAS II expression is weak in the innermost axons labeled with c739 and absent in the core. Scale bars, A: 25 μm; D: 50 μm. Abbreviations are the same as in Fig. 15.

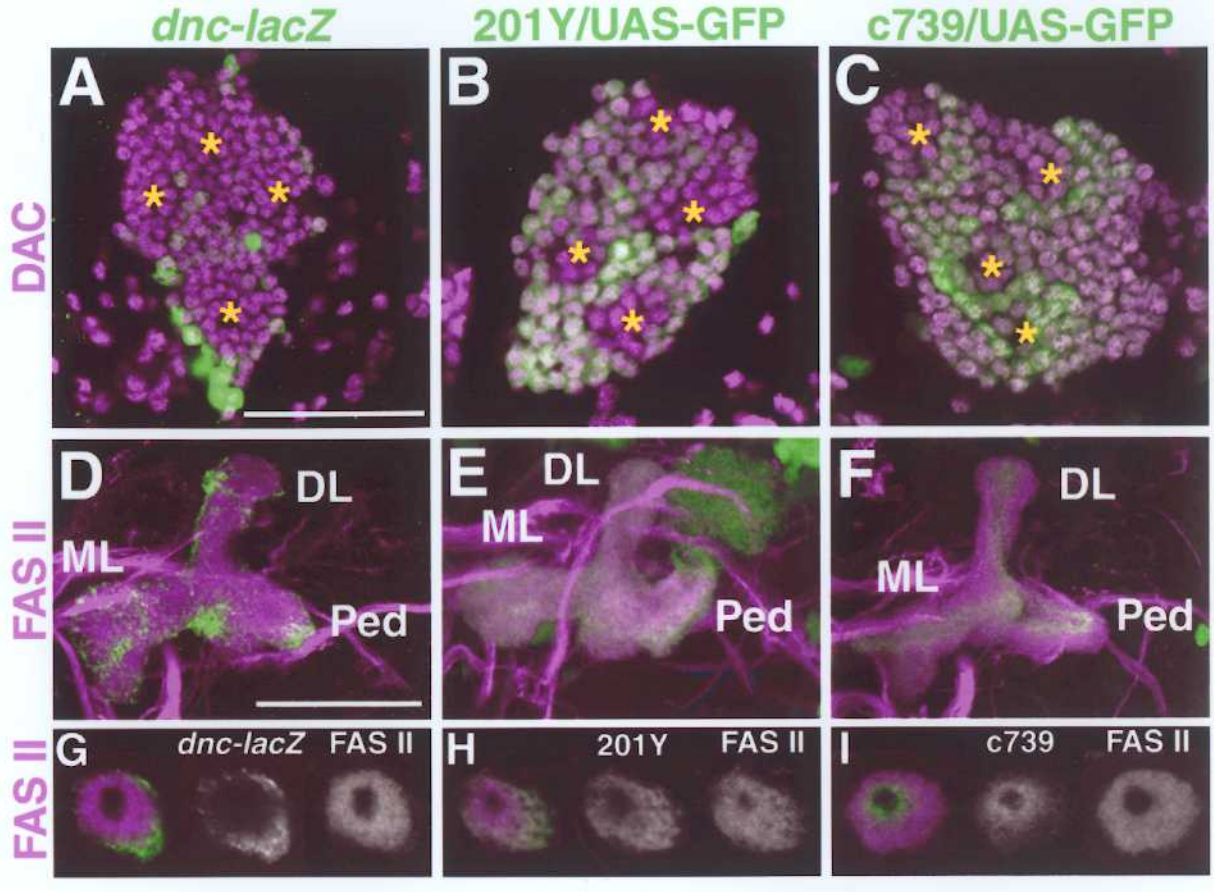

dnc-lacZ
201Y/UAS-GFP
c739/UAS-GFP
A
B
C
DAC
D
E
F
DL
ML
Ped
FAS II
G
H
I
dnc-lacZ
201Y
c739
FAS II

Figure 18. Distribution of *dnc-lacZ* neurons in the third instar MBs.

(A) Lateral view of a third instar MB double labeled with anti-Synaptotagmin (SYT: magenta/white) and anti-β-GAL (green/white) antibodies. Reconstruction of optical sections. (B) High magnification view of the dorsal lobe and heel showing a patchy distribution of the *dnc-lacZ* terminals. Single optical section. (C) A high power view of the dendritic arborization of the *dnc-lacZ* neurons in the calyx. Note the extensive arborization of the *dnc-lacZ* neurons around the globular synaptic terminals (arrowheads). Single optical section. Scale bars, A: 50 μm; B and C: 20 μm. Abbreviations are the same as in Fig. 15.

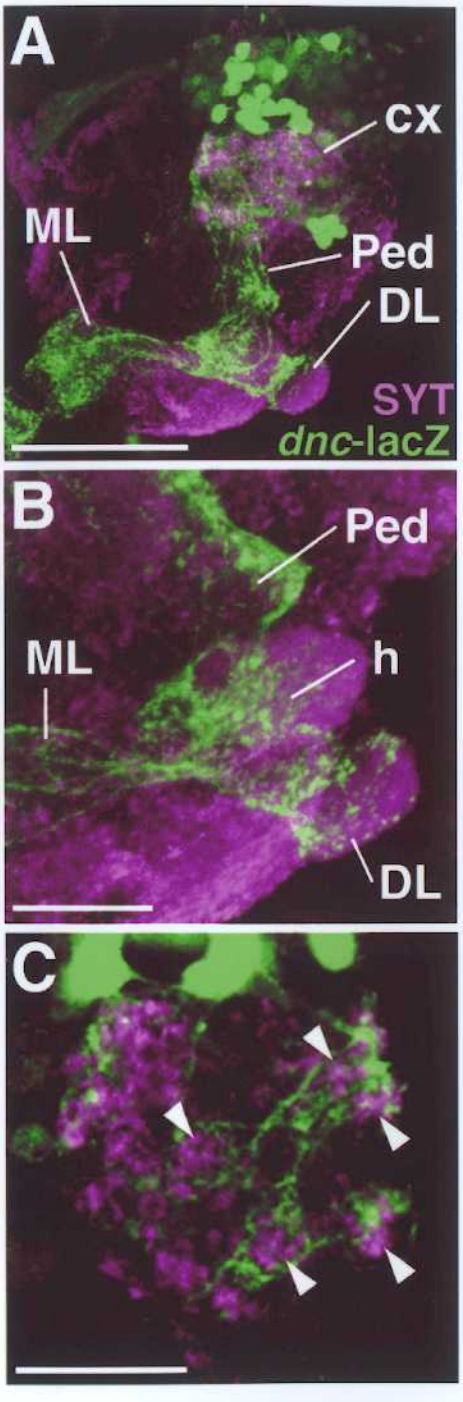

A
cx
ML
Ped
DL
SYT
dnc-lacZ
B
Ped
ML
h
DL
C

Figure 19. Characterization of the core fibers.

(A) Lateral view of wandering third instar MB labeled with an anti-FAS II antibody (magenta/white) and phalloidin (green/white). Single optical section. (B, C) MB axonal fibers around the calyces. MBs are labeled with *UAS-mCD8::GFP* (green/white) driven by 201Y and phalloidin (magenta/white). Single optical sections of wandering third instar MBs. (D-I) GFP reporter staining in wandering third instar MBs. *GAL4* drivers are *elav-GAL4* (D-F), OK107 (G, H) and 201Y (I). OK107 is expressed moderately in the MB neuroblasts and GMC and strongly in the differentiated Kenyon cells. The reporters are *UAS-mCD8::GFP* (green/white) (D, F-I) and *UAS-GFP* (green/white) (E). (D, G) Dorsal views of Kenyon cells labeled with anti-DAC antibody (magenta). (E, F, H, I) Lateral views of the lobes and the distal part of the peduncle labeled with anti-FAS II antibody. Note the core staining with the *elav-GAL4* and OK107 drivers. Insets are cross sections of peduncles. Scale bars, A-C, D: 20 μm. Abbreviations are the same as in Fig. 15. Stars in D and G indicate the positions of the neuroblasts.

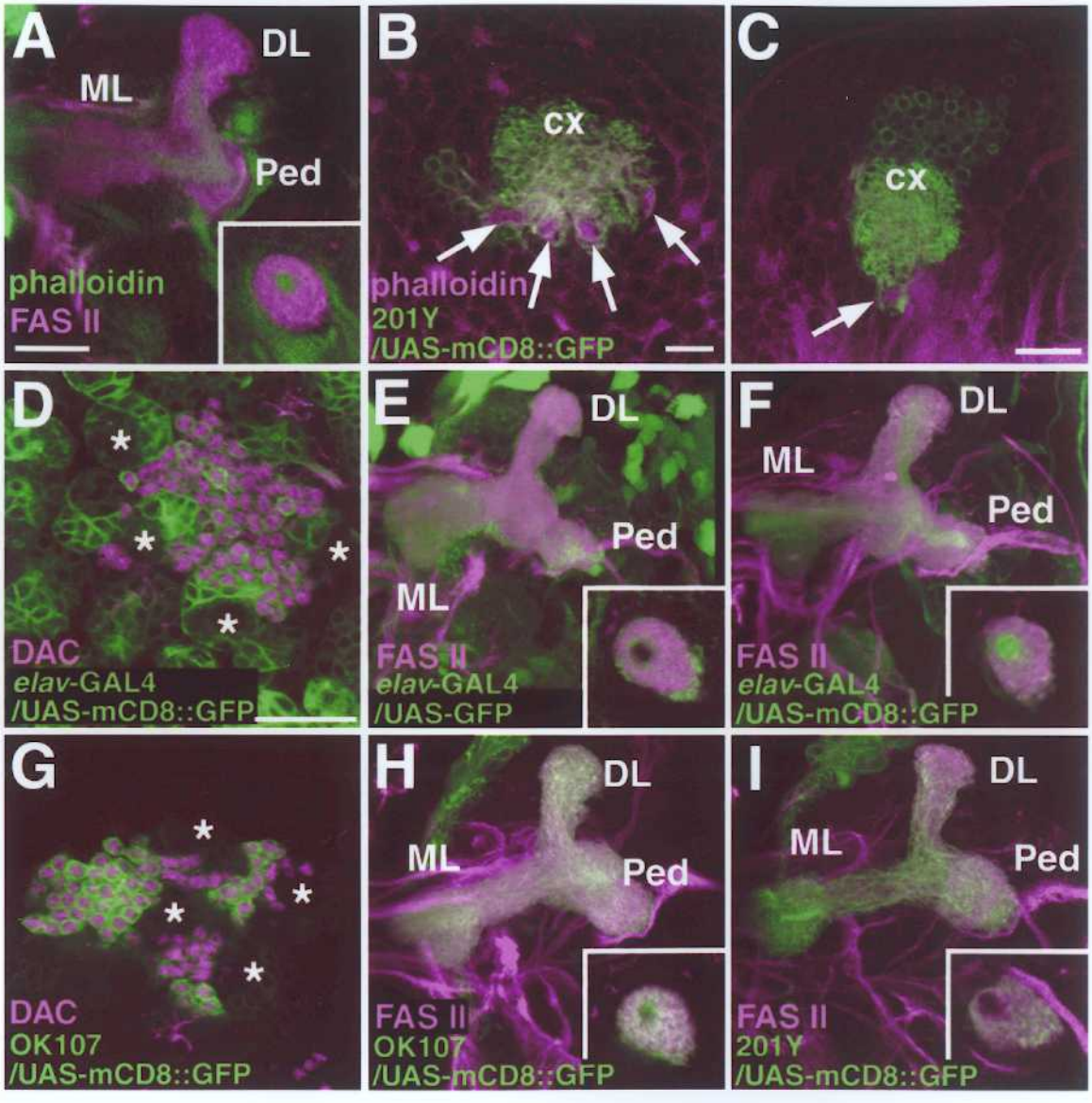

A
DL
ML
Ped
phalloidin
FAS II
B
cx
phalloidin
201Y
/UAS-mCD8::GFP
C
cx
D
DAC
elav-GAL4
/UAS-mCD8::GFP
E
DL
Ped
ML
FAS II
elav-GAL4
/UAS-GFP
F
DL
ML
Ped
FAS II
elav-GAL4
/UAS-mCD8::GFP
G
DAC
OK107
/UAS-mCD8::GFP
H
DL
ML
Ped
FAS II
OK107
/UAS-mCD8::GFP
I
DL
ML
Ped
FAS II
201Y
/UAS-mCD8::GFP

Figure 20. Summary of layer organization of the second and third instar larval MBs.

Layer organization of the second (A) and third instar larval MBs (B). Dorsal images of Kenyon cell clusters and cross sections of the peduncle and lobes. Corresponding subdivisions are shown in same colours. Relative expression levels of various MB markers are summarized in the tables. The second instar MBs can be concentrically subdivided in two layers surrounding the core. With increase in the numbers of the Kenyon cells and their projections, the third instar MBs can be subdivided into three layers surrounding the core. Note that the disto-proximal subdivisions of each of the four Kenyon cell clusters topologically correspond to the unified concentric subdivisions in the lobes and the peduncle. The core consists of a bundle of newly formed axon fibers containing densely packed actin filaments. DNC, *dnc-lacZ*; AF, actin filaments.

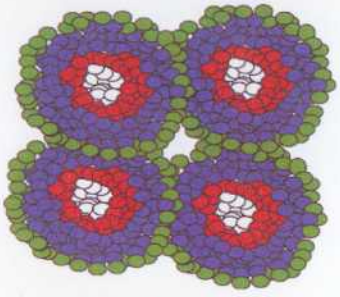
A Second instar MBs

KC clusters

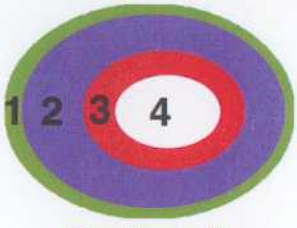
Peduncle and lobes

	DNC	FAS II	201Y	c739	OK107	AF
1. Surface layer	++	+	++	++	++	+
2. Middle layer	-	++	+	++	++	+
3. Core	-	-	-	-	+	++

B Third instar MBs



KC clusters



Peduncle and lobes

	DNC	FAS II	201Y	c739	OK107	AF
1. Surface layer	++	+	++	-	++	+
2. Outer layer	-	++	++	+	++	+
3. Inner layer	-	+	±	++	++	+
4. Core	-	-	-	-	+	++

Figure 21. Sequential generation of the MB neurons and their projections.

(A, D) Neuroblast clone (green/white) induced in the first instar. (B, E) Two-cell clone induced in the first instar. (C, F) Neuroblast clone induced at the beginning of the third instar. Clones are labeled with *elev-GAL4* and *UAS-mCD8::GFP*. (A-C) Dorsal views of the Kenyon cells labeled with anti-EY (blue). Late third instar stage. Stars indicate the location of the four-MB neuroblasts. The position of the GFP marked neuroblast is labeled with a yellow star. (D-F) Lateral views showing the peduncle, dorsal and medial lobes. Insets in D-F are optical cross sections of the peduncles. The peduncle and lobes are labeled with anti-FAS II (magenta). Arrow in the inset indicates the core. DL, dorsal lobe; ML, medial lobe; Ped, peduncle; cx, calyx. Scale bars, A and D: 40 μm. Genotype: *GAL4*^{c155}, *hs-FLP/X or Y; G13, UAS-mCD8::GFP/G13, tubP-GAL80.*

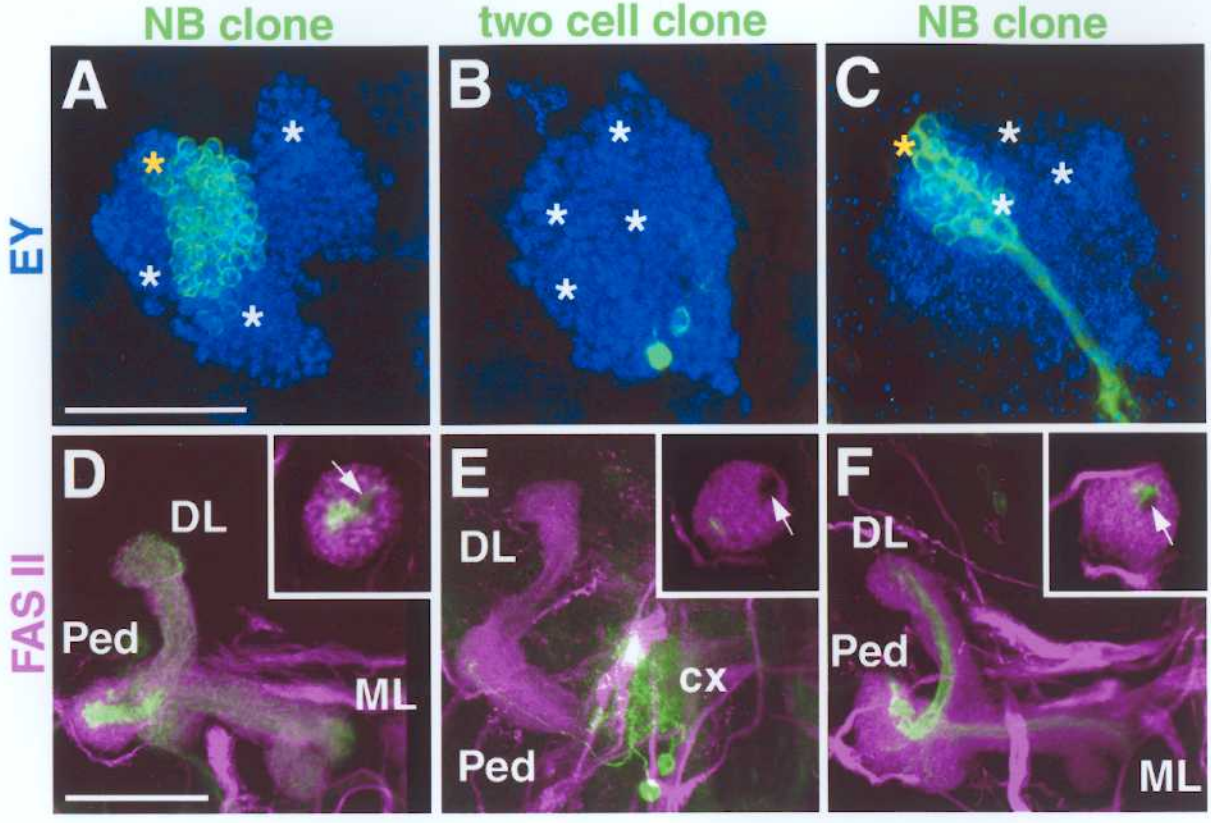

NB clone
two cell clone
NB clone
A
B
C
EY
D
E
F
DL
DL
DL
Ped
ML
cx
Ped
Ped
ML
FAS II

Figure 22. Structural MB defects in loss-of-function *fas II* mutants.

(A) Axonal projections of embryonic MB primordium in fas II^{eb112} mutant (protein null). Lateral view of the embryonic brain at late stage 16. FAS II (magenta) and 238Y (green). Single optical section. The embryonic MBs are labeled with *UAS-tau-lacZ* and 238Y-*GAL4*. Arrows indicate the growing MB axons. (B) Overview of an embryonic MB primordium in fas II^{eb112}. Reconstruction of optical sections. Same embryo as in A. Neurons are labeled with anti-HRP antibody (white). 238Y signal (green) is selectively enhanced. (C, D) Third instar larval MBs double labeled with anti-FAS II (magenta/white) and anti-DIF (green/white), which stains MB structures (Cantera et al., 1999). (C) *fas* II^{e76} hypomorphic (10%) mutant. Note the thin dorsal lobe (arrowhead) and fusion of the medial lobes. (D) *fas* II^{e86} hypomorphic (50%) mutant. Note the small dorsal lobe (arrowhead) and the medial lobes (arrow). Calyces are markedly expanded with aberrant accumulation of the FAS II protein. (E, F) *fas* II^{eB112} mutant clones at the late third instar stage (green/white). Mitotic recombination was induced in the first instar stage. (E) Dorsal view of the Kenyon cells labeled with anti-EY (blue). Stars, neuroblasts. (F) Lateral view showing the peduncle, dorsal and medial lobes labeled with anti-FAS II (magenta/white). Inset shows a cross section of the peduncle. The core fibers are not labeled due to the driver/reporter combination used for the generation of the mosaic clones. Genotype: *hs-FLP, tubP-GAL80, FRT19A/ fas* II^{eB112}*, FRT19A; 201Y/ UAS-GFP-T2*. Ped, peduncle; DL, dorsal lobe; ML, medial lobe; cx, calyx. Scale bars, A and B: 10 μm; C: 50 μm; E and F: 20 μm.

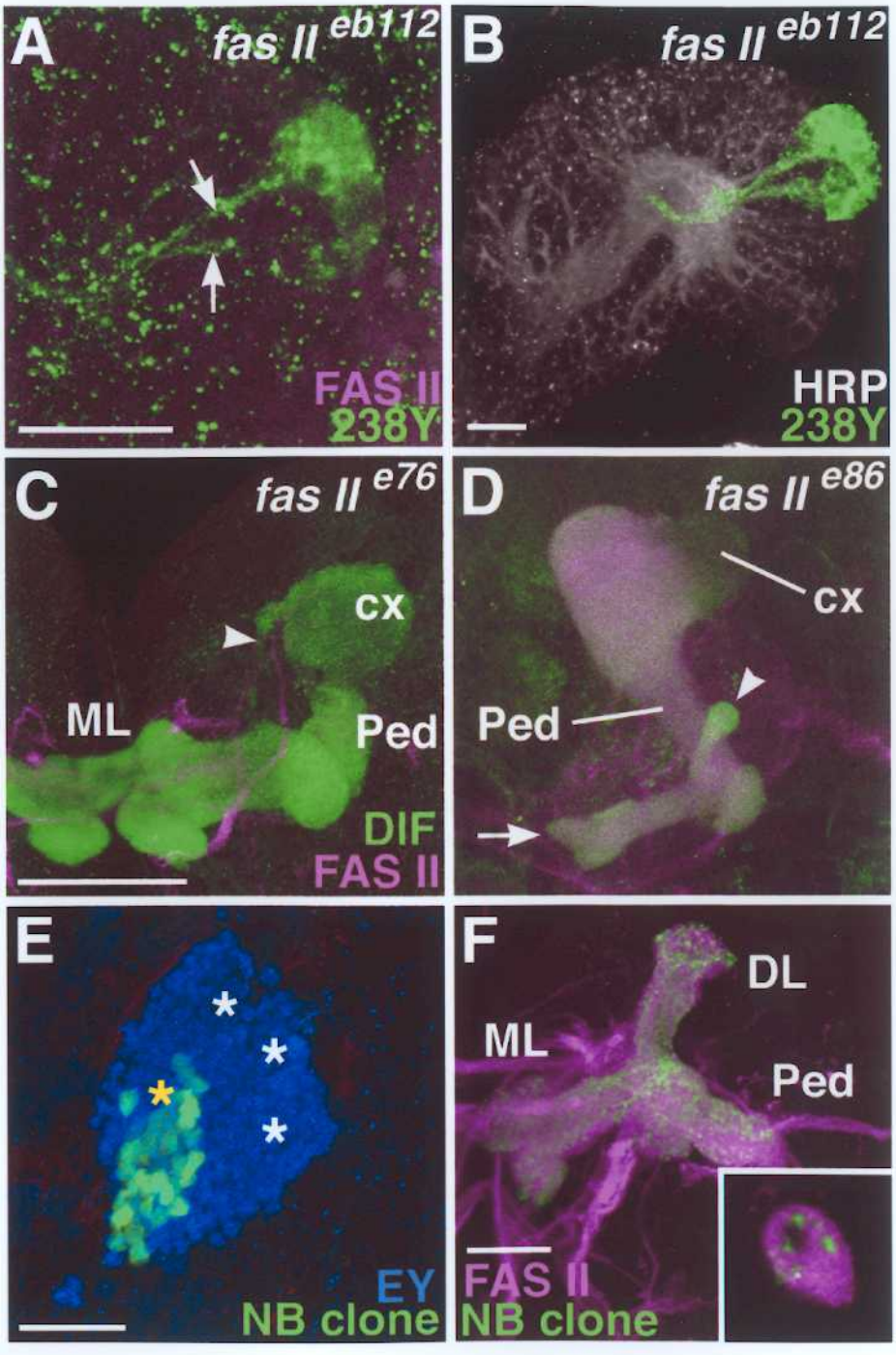

A
fas II eb112
FAS II
238Y
B
fas II eb112
HRP
238Y
C
fas II e76
cx
ML
Ped
DIF
FAS II
D
fas II e86
cx
Ped
E
EY
NB clone
F
DL
ML
Ped
FAS II
NB clone

Figure 23. Structural MB defects caused by overexpression of FAS II.

Lateral views of larval MBs at wandering third instar stage. *GAL4* drivers are *elav-GAL4* (A), OK107 (B-D), 201Y (E), 238Y (F). Reporters are *UAS-mCD8::GFP* in all cases (green). Insets show cross sections of peduncles with phalloidin staining (magenta). Arrowhead in A, malformed thin dorsal lobe. (B) MB of type 1 defects. Note the blunt medial lobe as compared to the wild-type medial lobe in F which terminate in three blobs. (C) MB of type 2 defects. Note the malformed thin dorsal lobe (arrowhead). (D) MB of type 3 defects. Note the malformed medial lobe (arrowhead) and expansion of the dorsal lobe. Scale bar, 20 μm. Ped, peduncle; DL, dorsal lobe; ML, medial lobe.

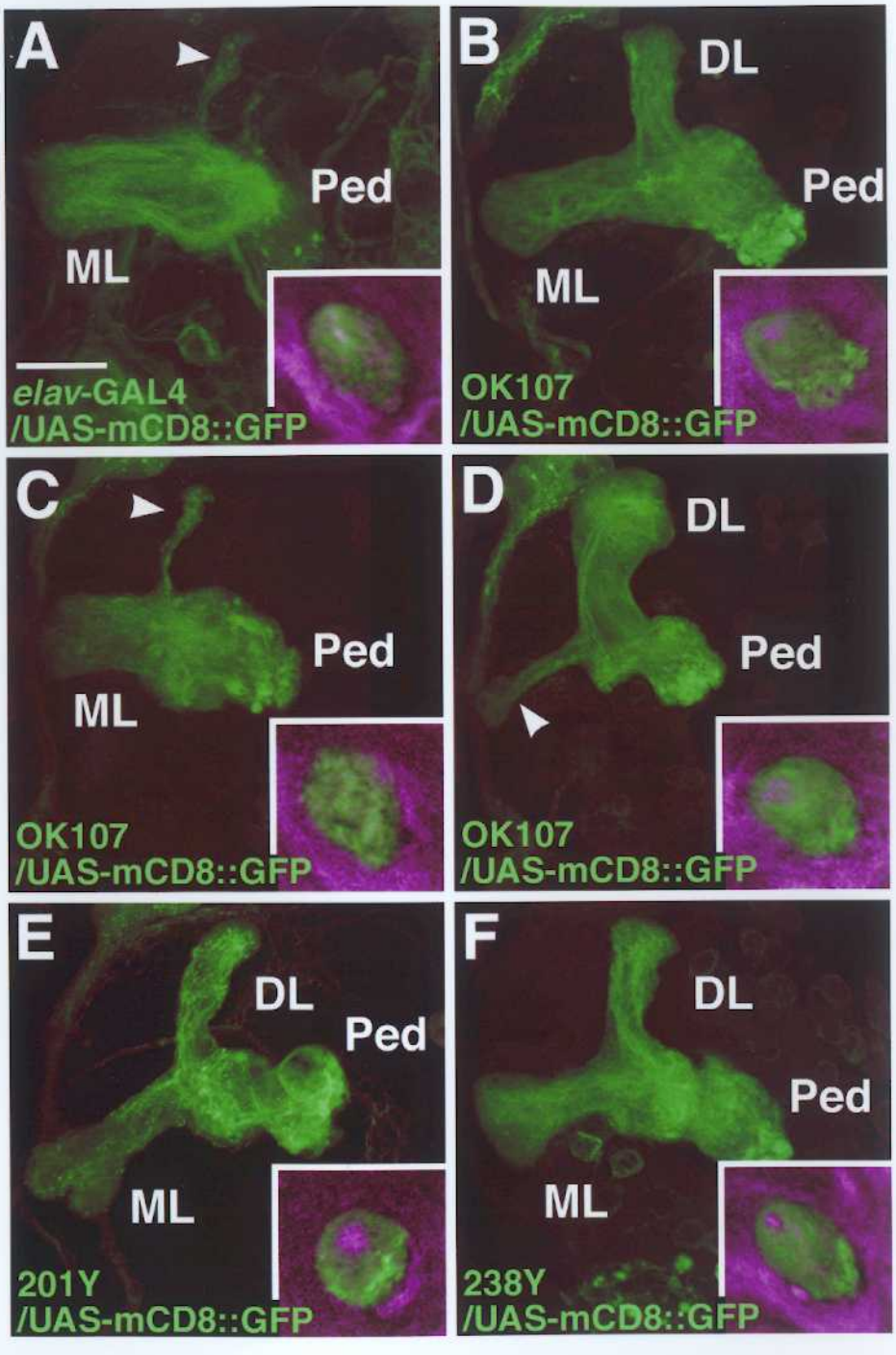
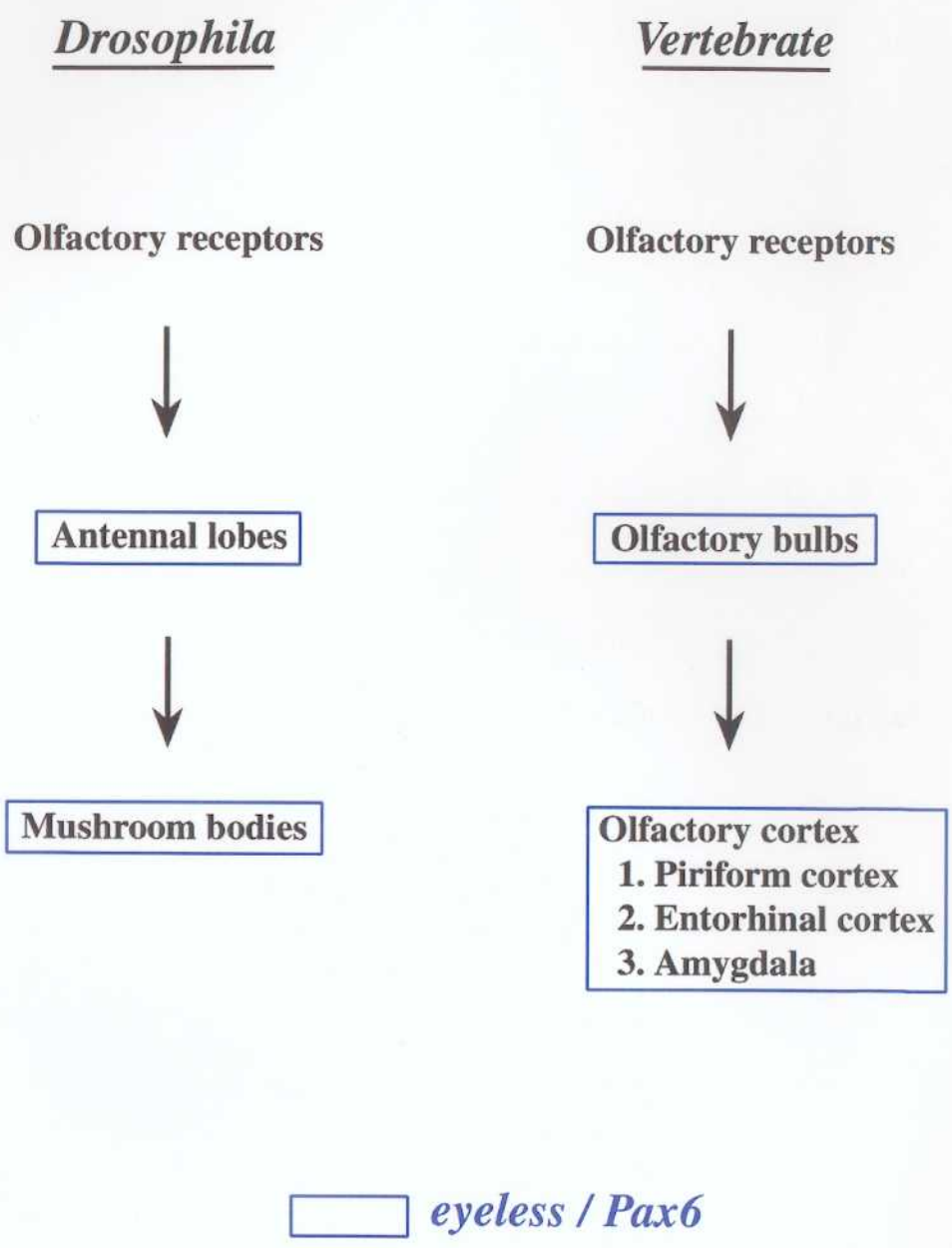

A
Ped
ML
elav-GAL4
/UAS-mCD8::GFP
B
DL
Ped
ML
OK107
/UAS-mCD8::GFP
C
Ped
ML
OK107
/UAS-mCD8::GFP
D
DL
Ped
OK107
/UAS-mCD8::GFP
E
DL
Ped
ML
201Y
/UAS-mCD8::GFP
F
DL
Ped
ML
238Y
/UAS-mCD8::GFP

Figure 24. Neural Pathways for olfactory information and learning.

In *Drosophila*, olfactory cues are sensed by the olfactory receptor neurons on the antenna. The signals are first transmitted via the olfactory axons to glomeruli of the antennal lobes. From the antennal glomeruli, projection neurons send axons to the MBs. In vertebrate, olfactory cues are sensed by the olfactory receptor neurons on the olfactory epithelium. Odorant signals are then transmitted to the glomeruli of the olfactory bulbs. Olfactory bulb neurons project axons to the olfactory cortex, which harbors piriform cortex, entorhinal cortex and amygdala.


Drosophila
Vertebrate
Olfactory receptors
Olfactory receptors
Antennal lobes
Olfactory bulbs
Mushroom bodies
Olfactory cortex
1. Piriform cortex
2. Entorhinal cortex
3. Amygdala
eyeless / Pax6