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teaching only

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other purposes than learning

Genes, Brains and Behaviour: Lecture 6

Optomotor behaviour

Karl-Friedrich Fischbach, Neurogenetics, Freiburg

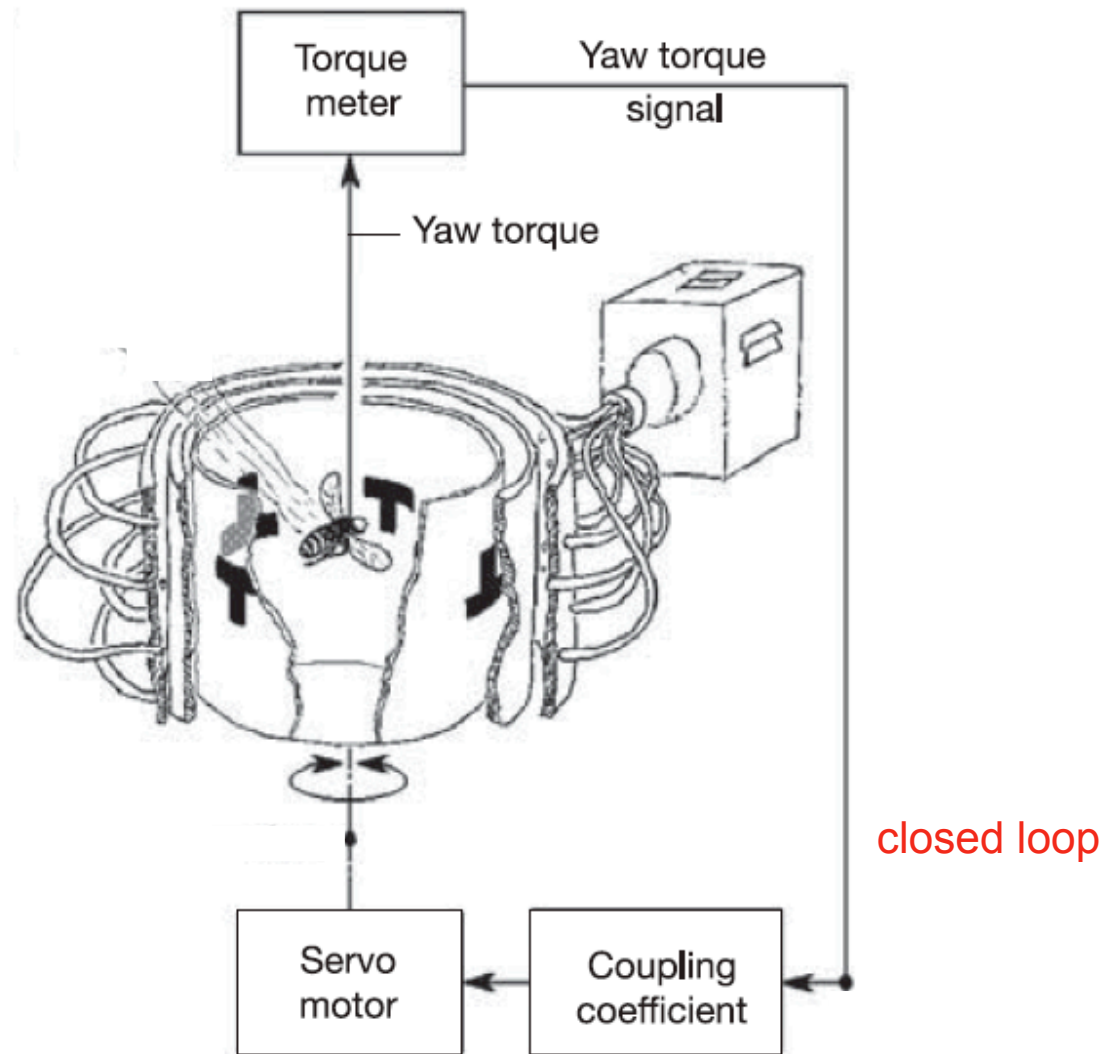


Vision of motion
Optomotor responses

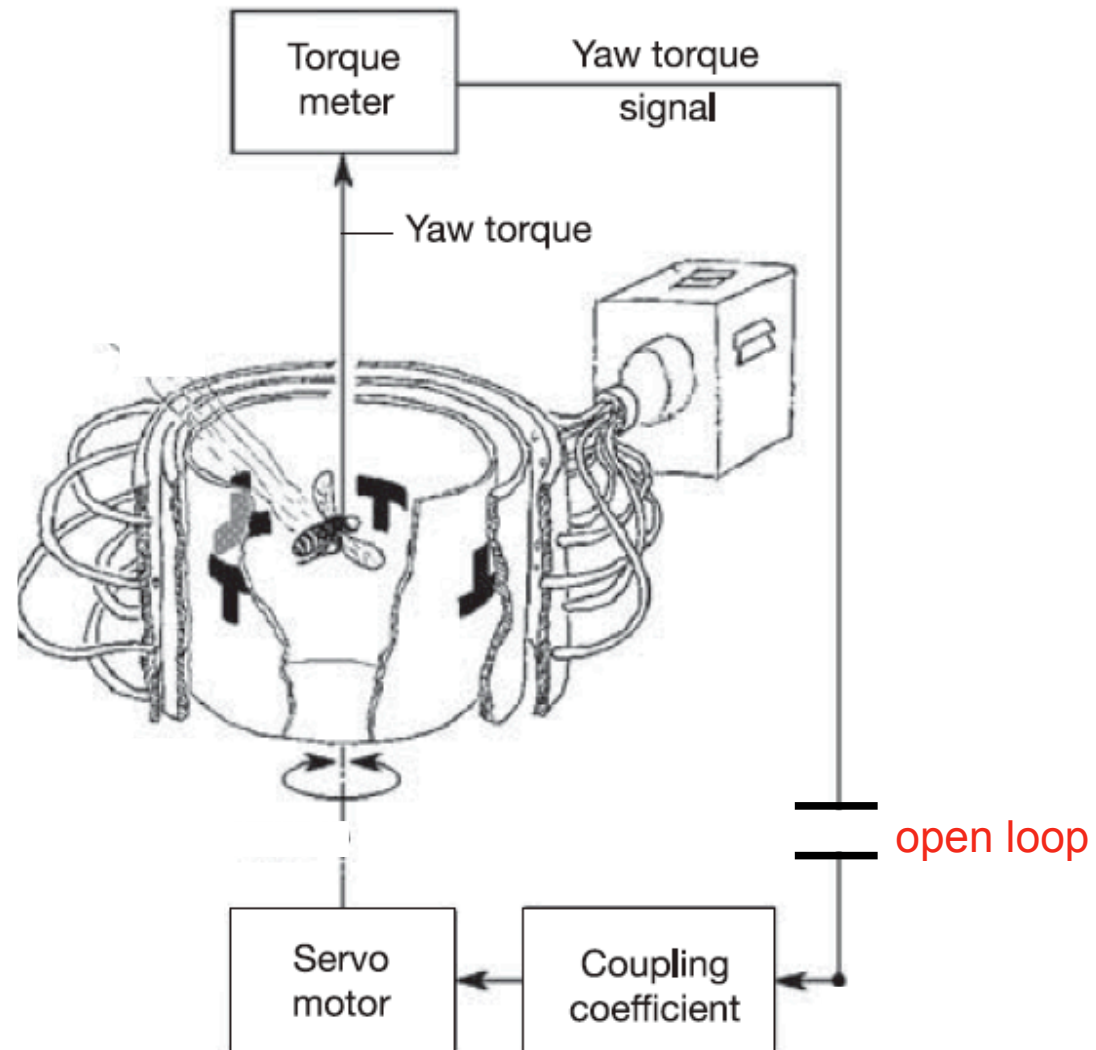
The search for the elementary movement detectors in *Drosophila*

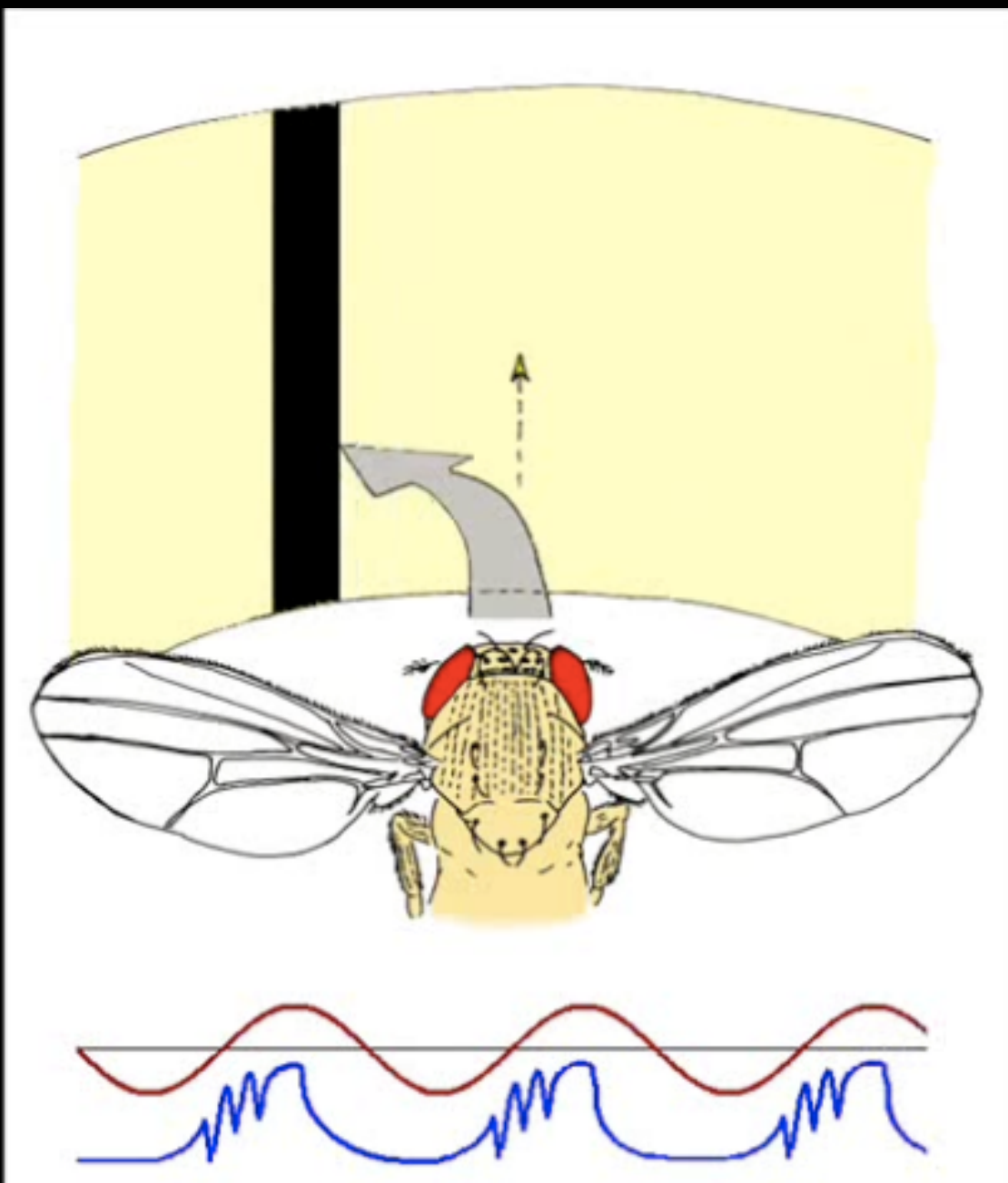


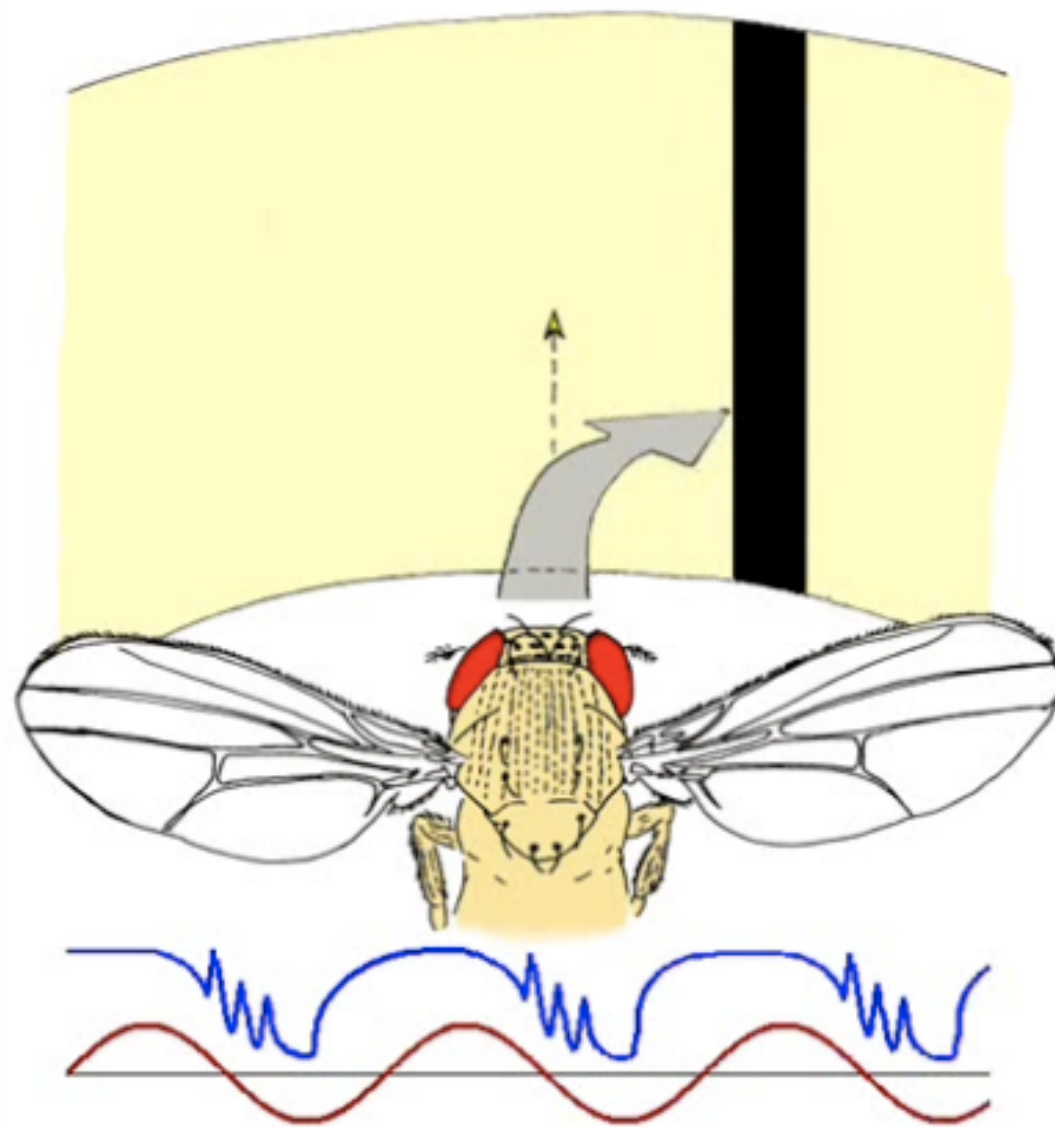
Flight at the torque meter

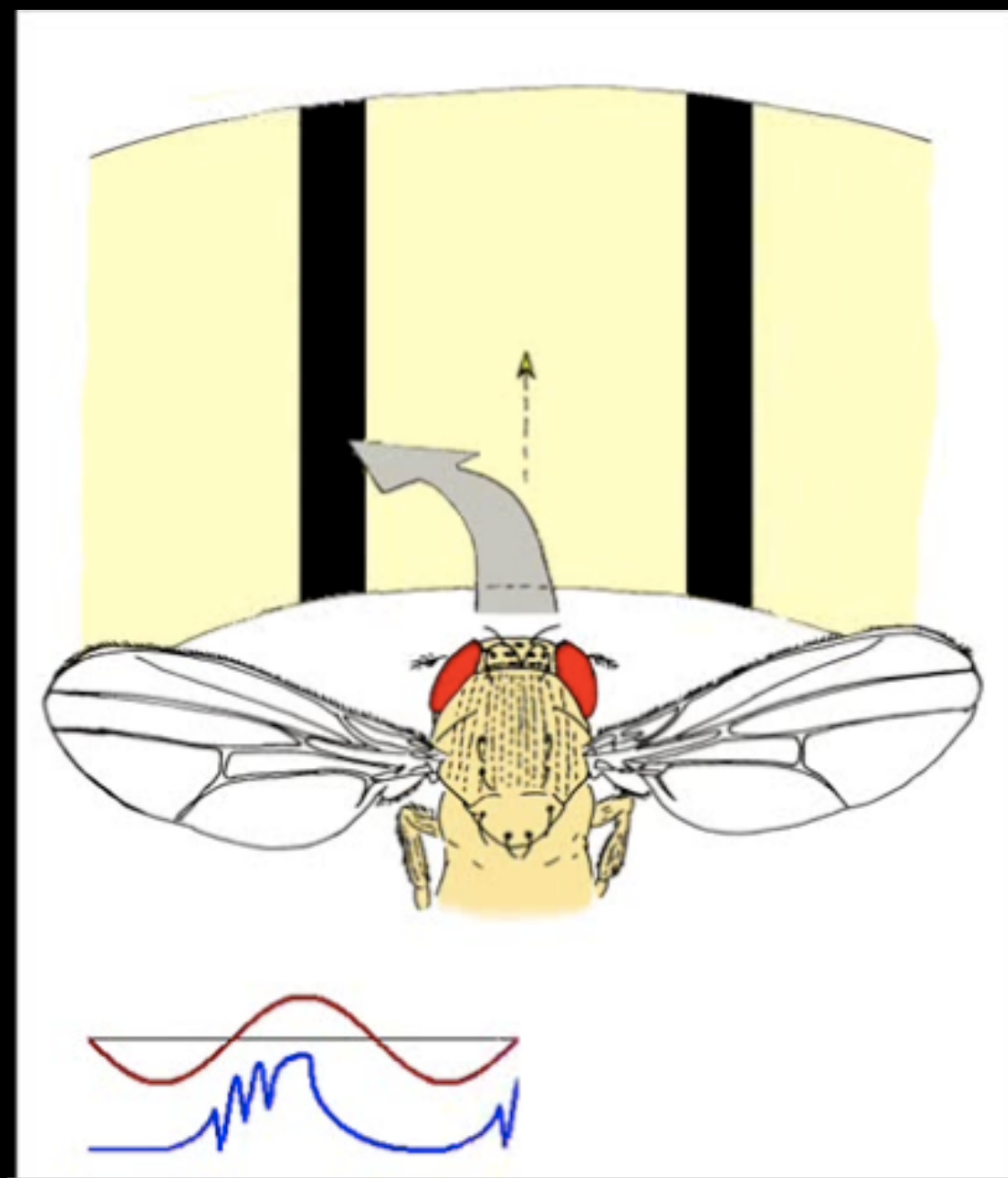


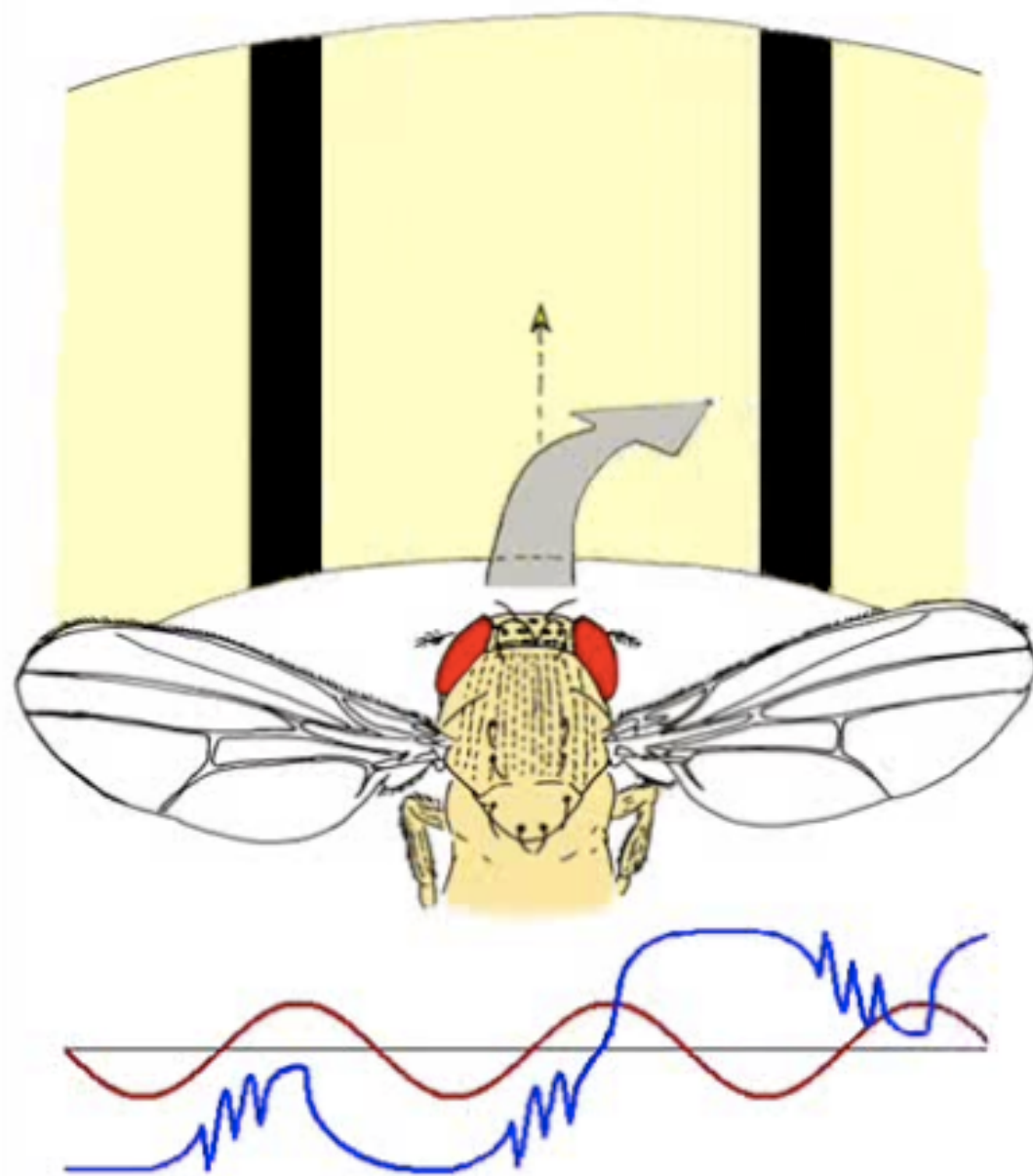
Flight at the torque meter





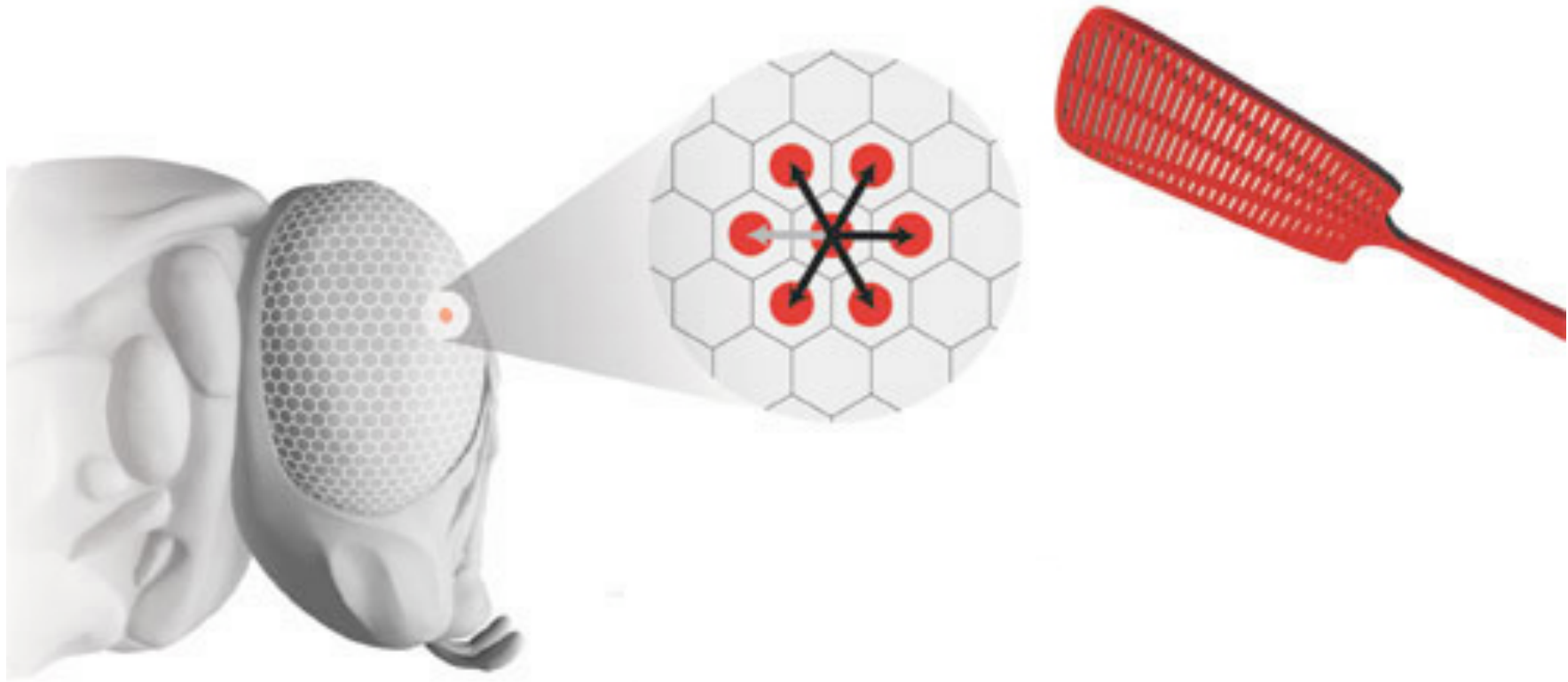




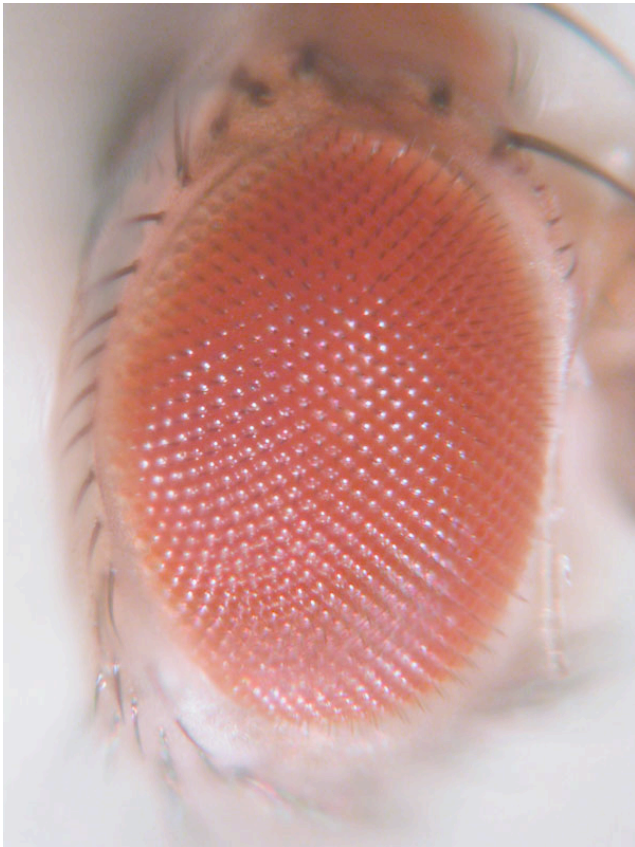


How is motion detected in flies?

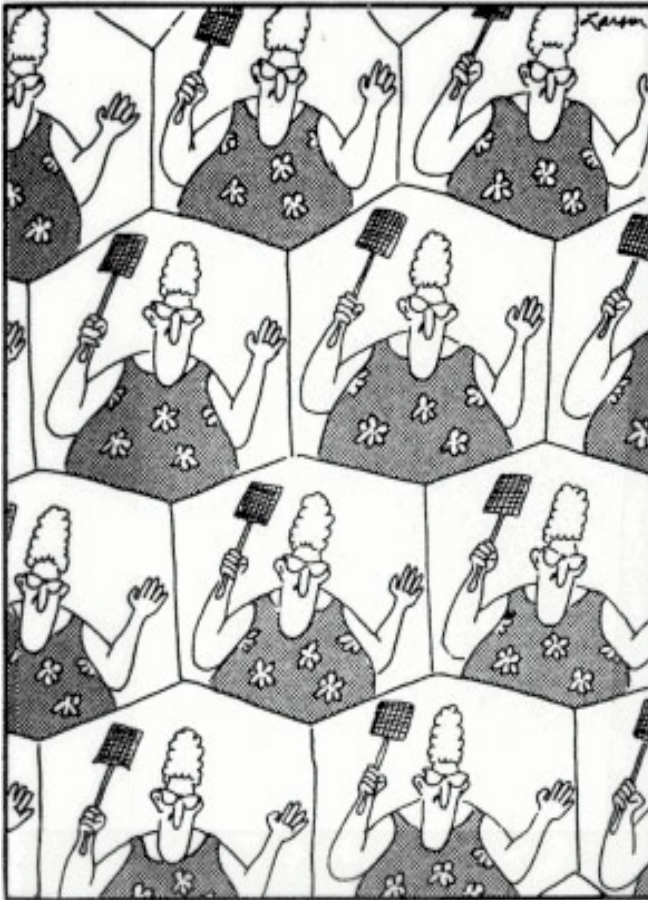
What is the neural implementation?



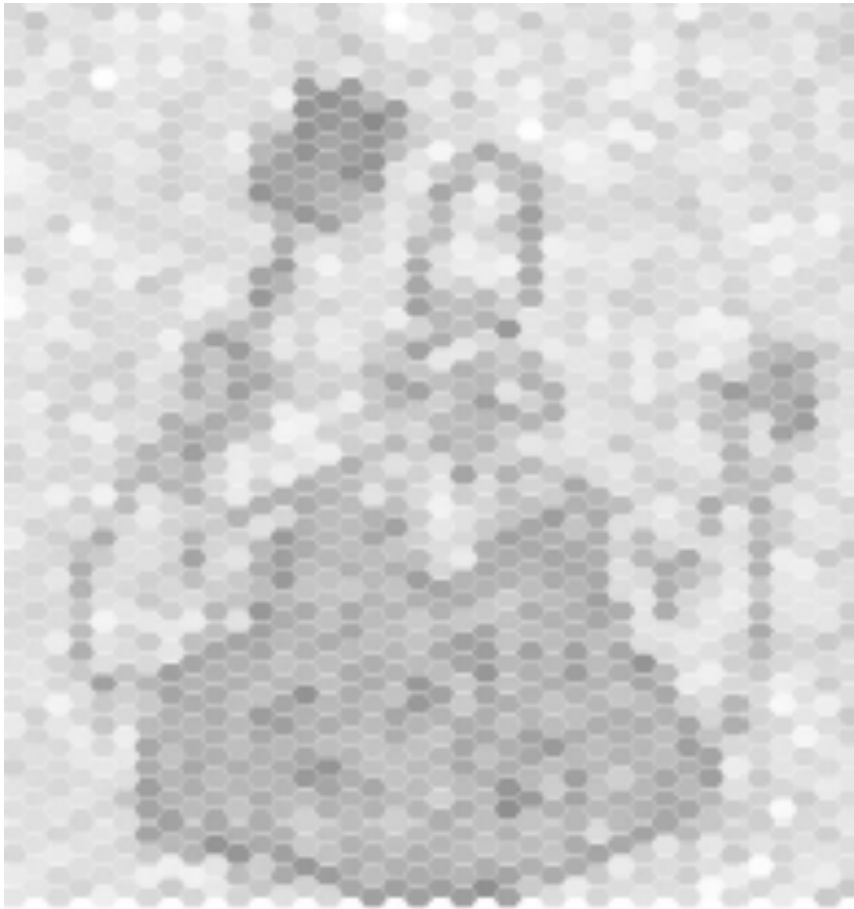
How flies (do not) see

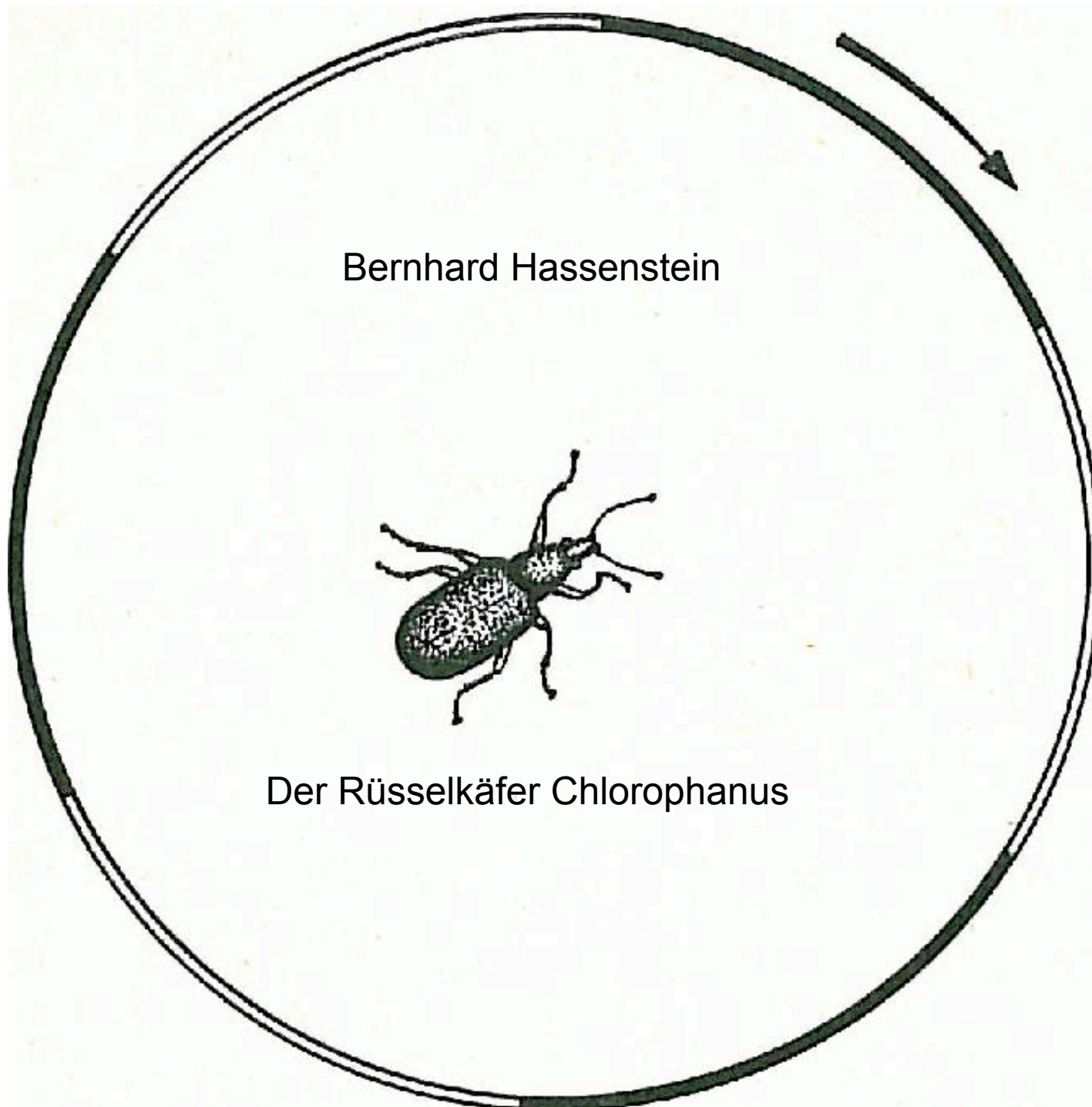


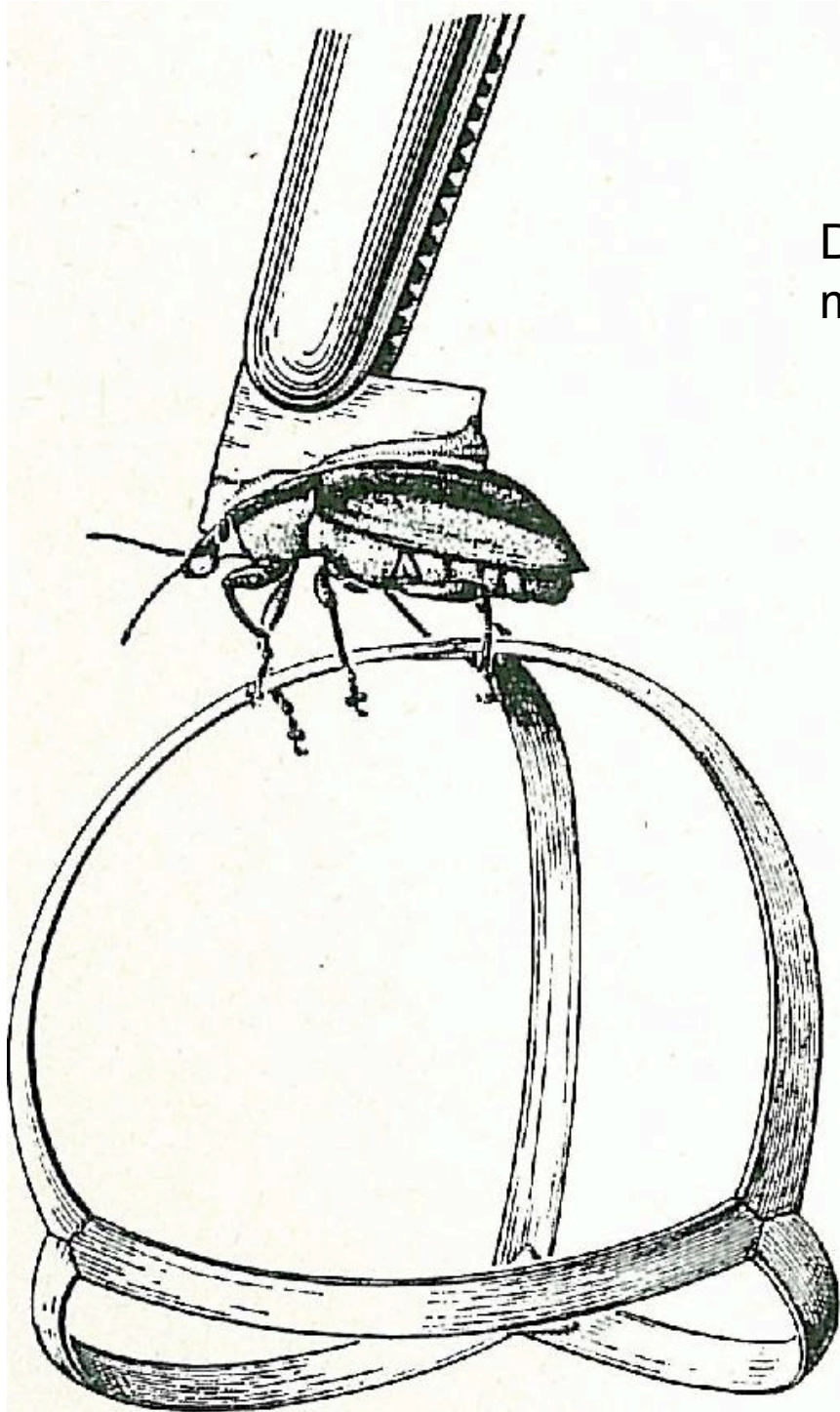
How flies (do not) see



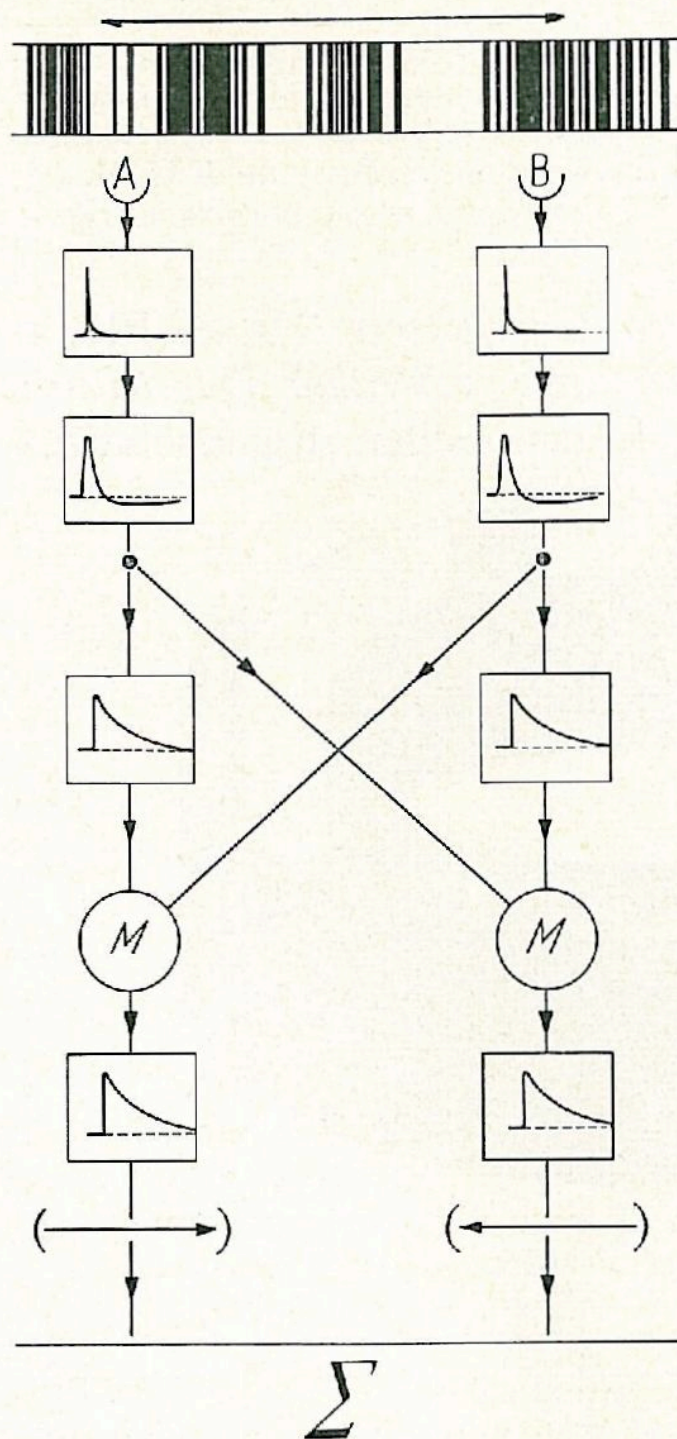
How flies (do not) see







Der Rüsselkäfer *Chlorophanus*
mit dem "Spangenglobus"



bewegtes Muster

Helligkeitsempfindliche
Aufnahmeelemente

Transformation nach einer
gewöhnlichen linearen
Differentialgleichung,
 $\tau = 0,03$ sec. „H-Instanz“.

Transformation nach einer
partiellen linearen
Differentialgleichung.
„D-Instanz“.

Transformation nach einer
gewöhnlichen linearen
Differentialgleichung.
 $\tau = 1,6$ sec. „F-Instanz“.

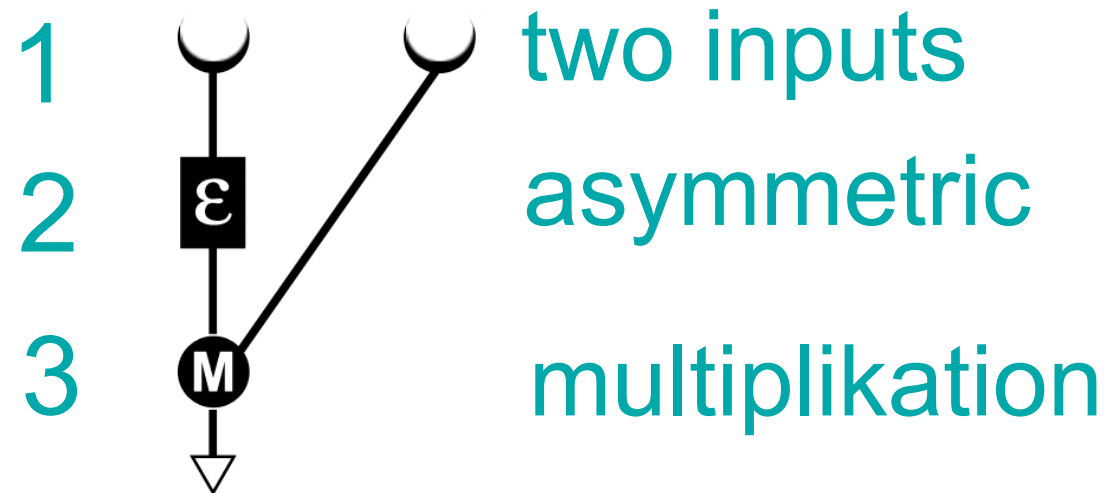
Multiplikation nach Betrag
und Vorzeichen.

Träges Übertragungsglied.
Zeitkonstante: einige sec.

Richtung der durch posi-
tive Werte ausgelösten
Wendereaktion der Tiere.

Vektorielle Summation.

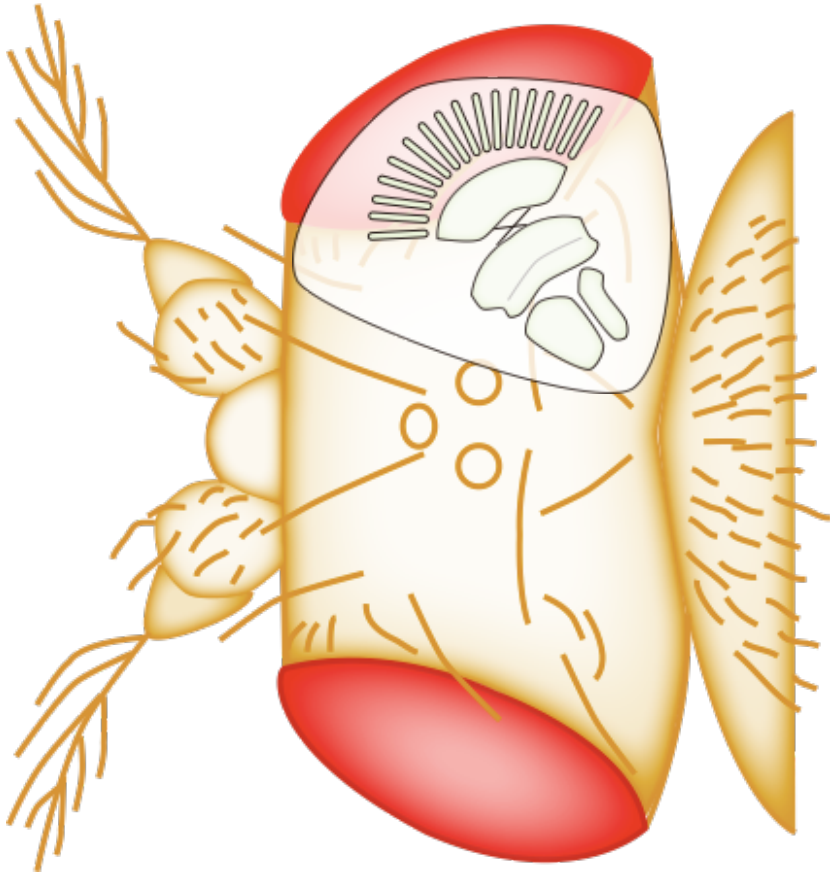
motion detection



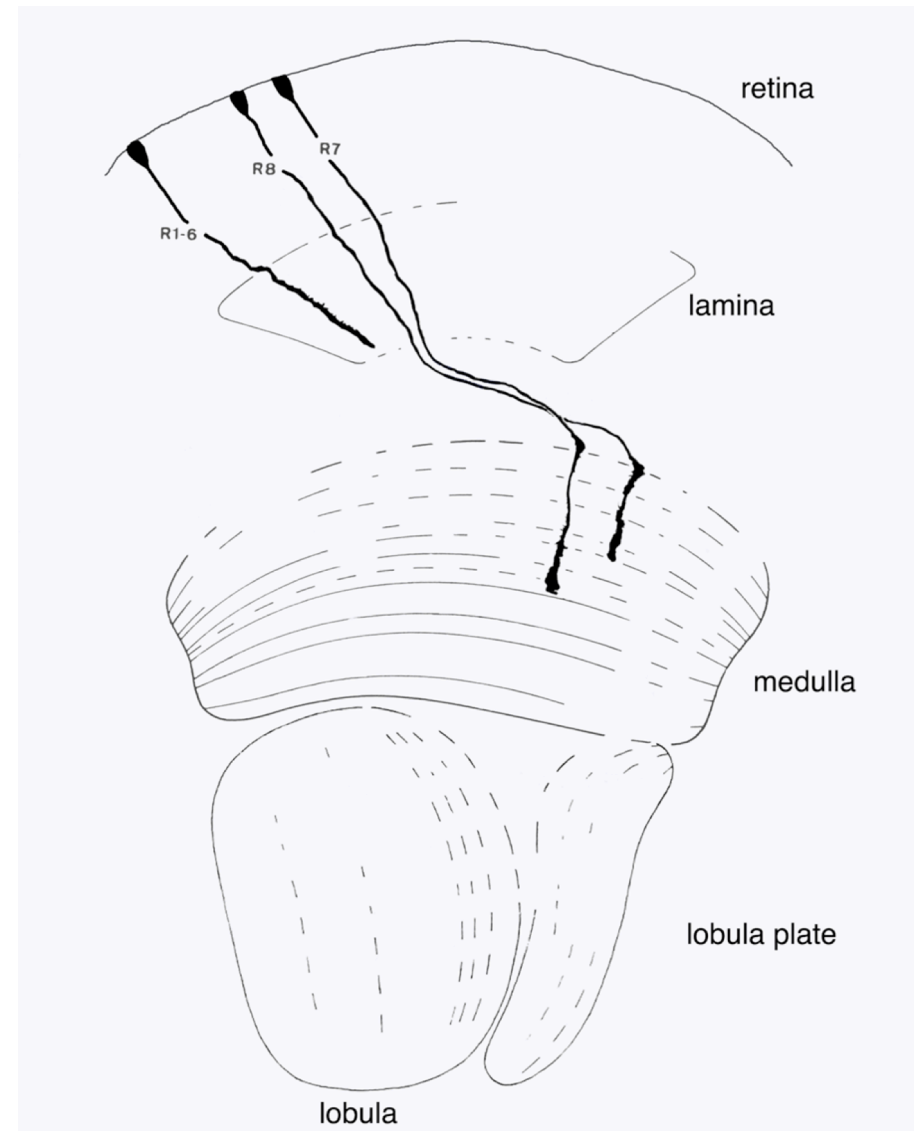
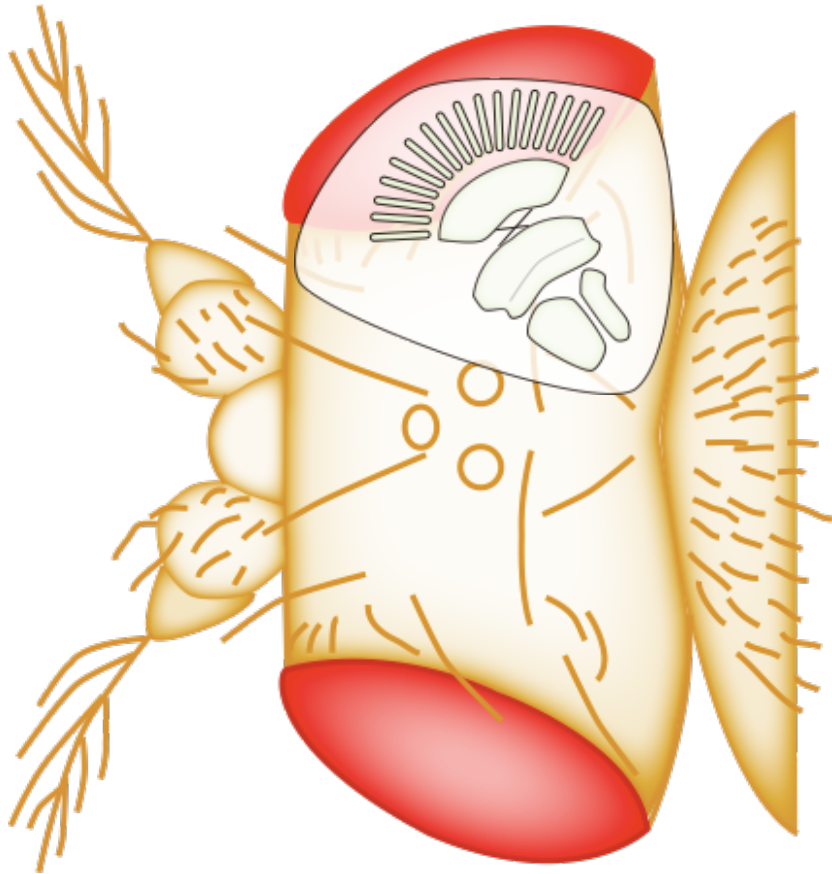
Hassenstein and Reichardt, 1953; Borst and Egelhaaf, 1989

The „elementary motion detector“ (EMD) is the smallest unit able to respond to the direction of motion

Visual system of *Drosophila*

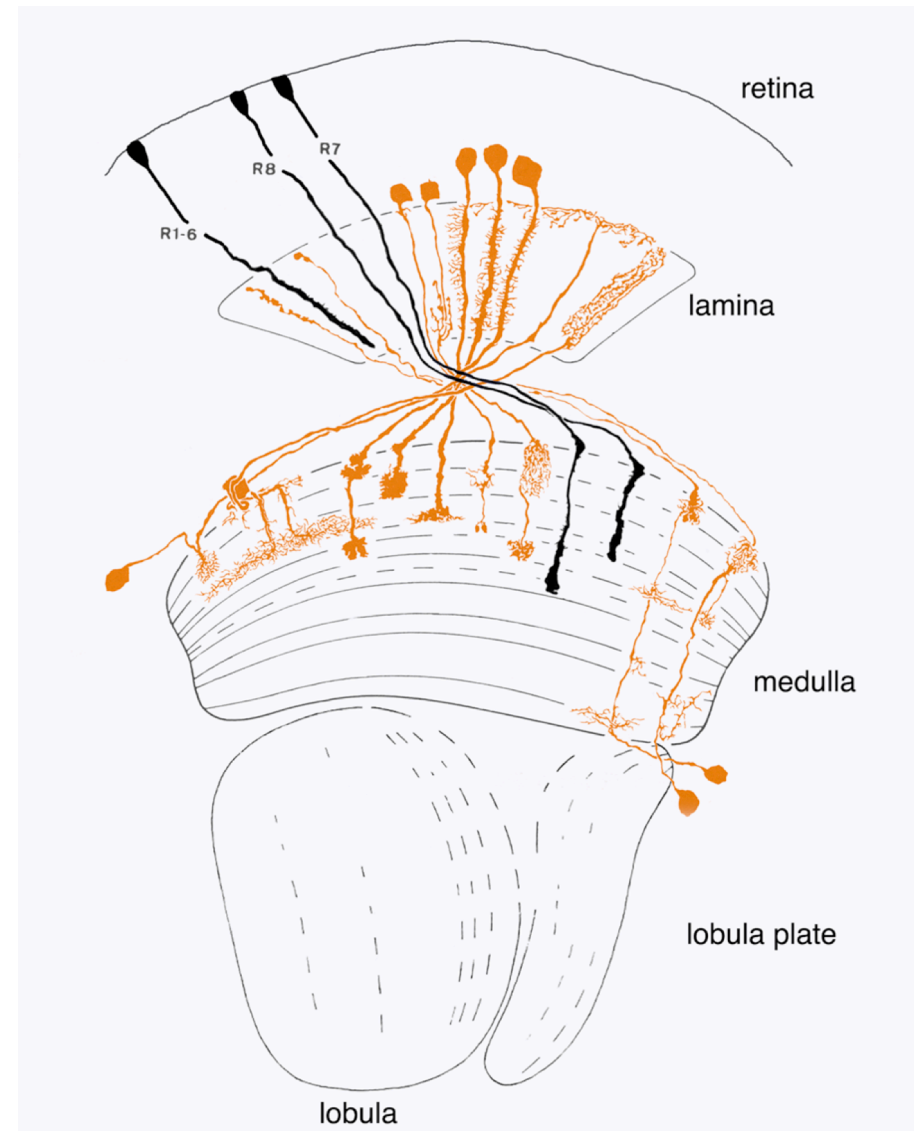
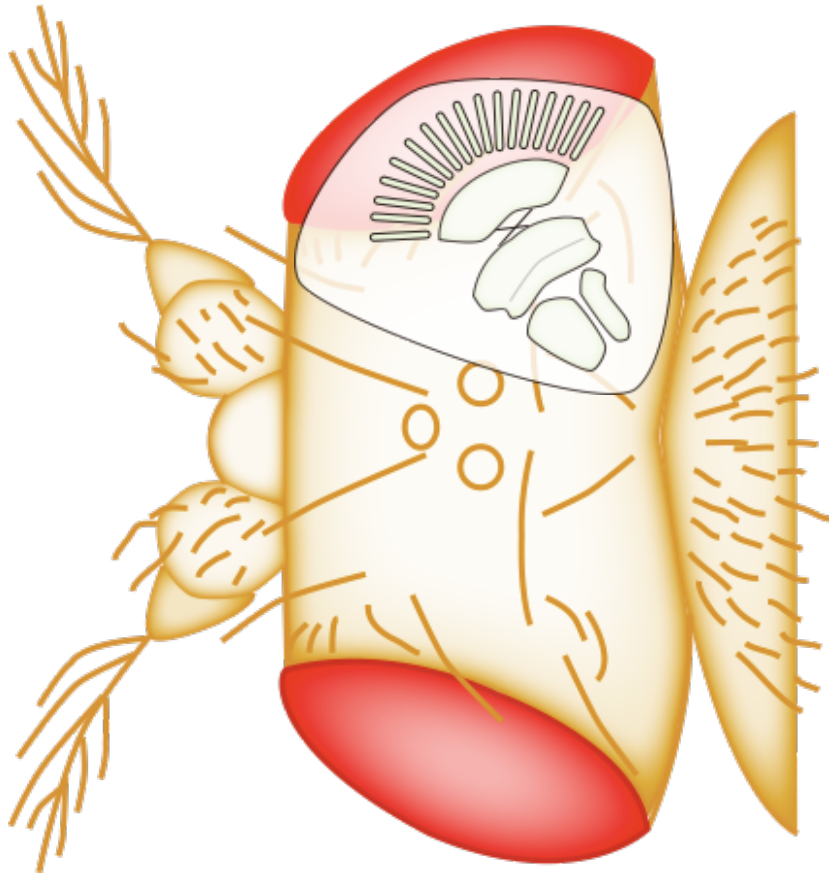


Visual system of *Drosophila*



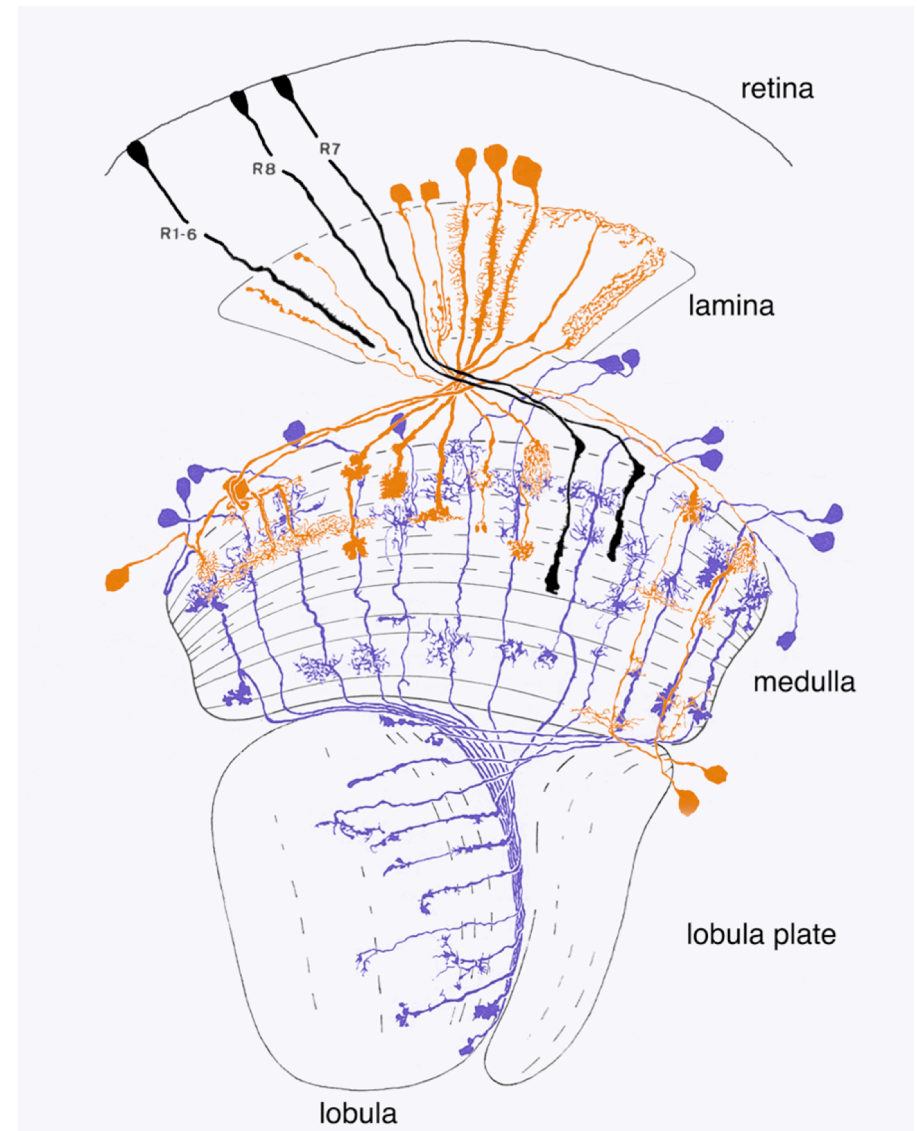
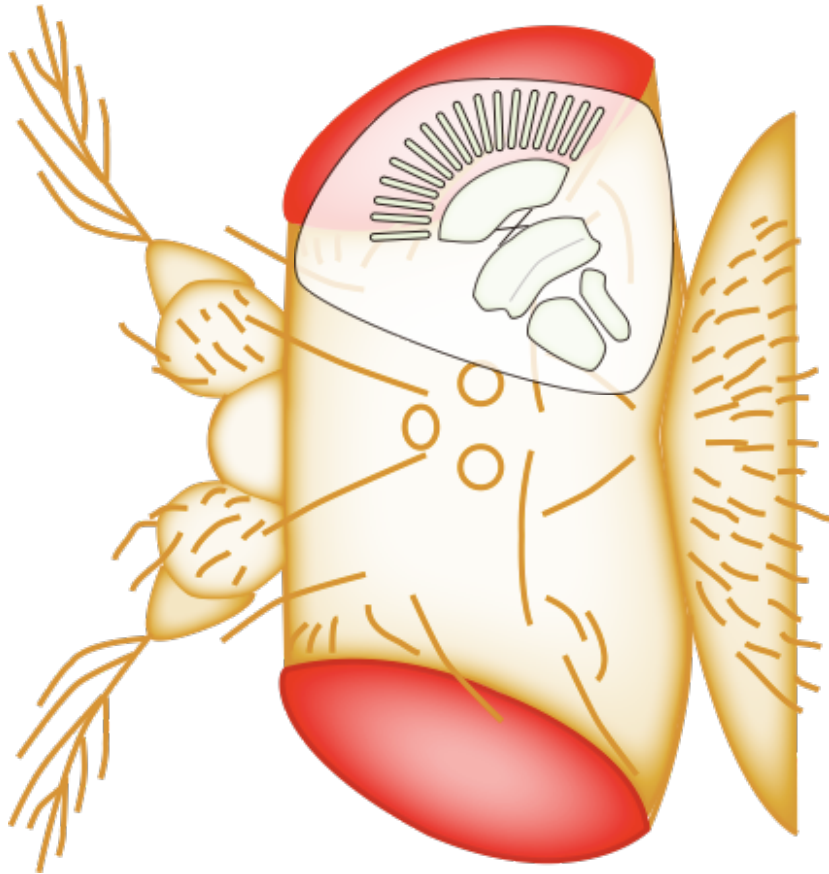
photoreceptors

Visual system of *Drosophila*



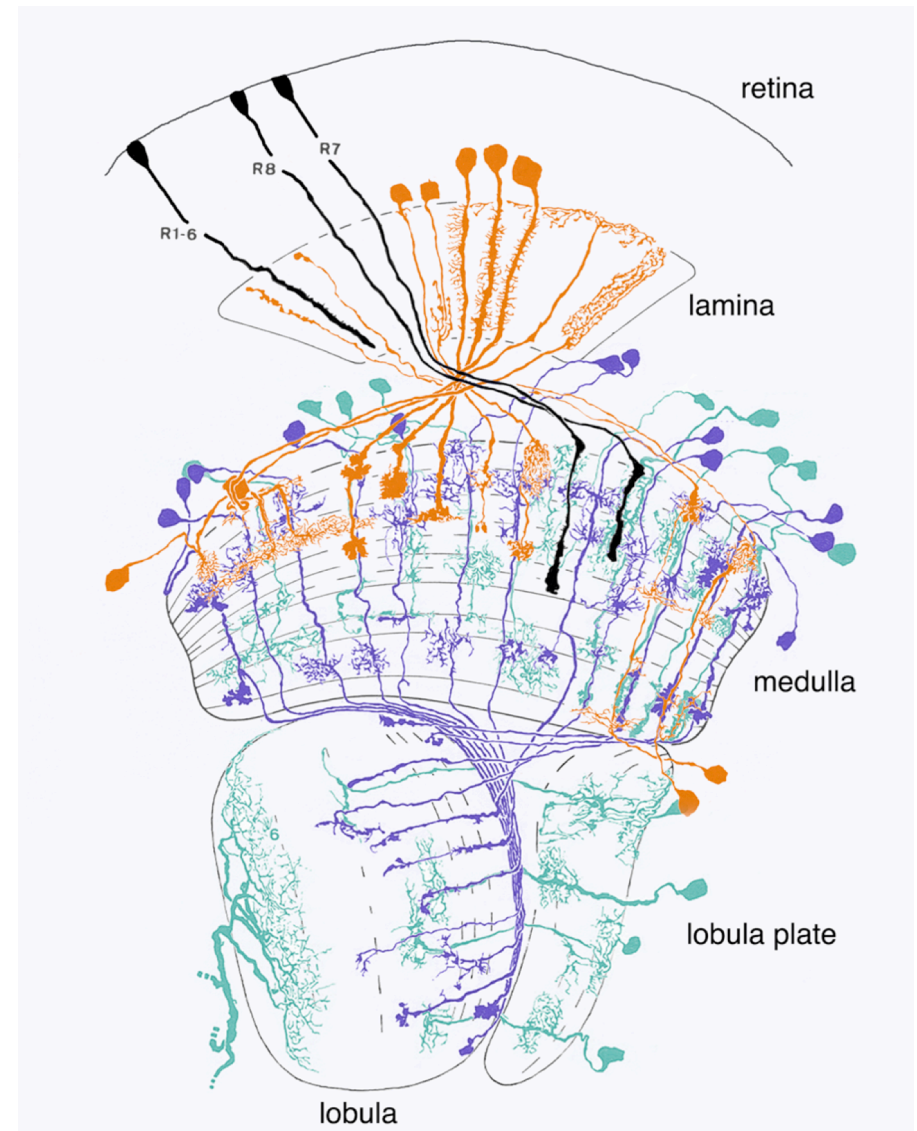
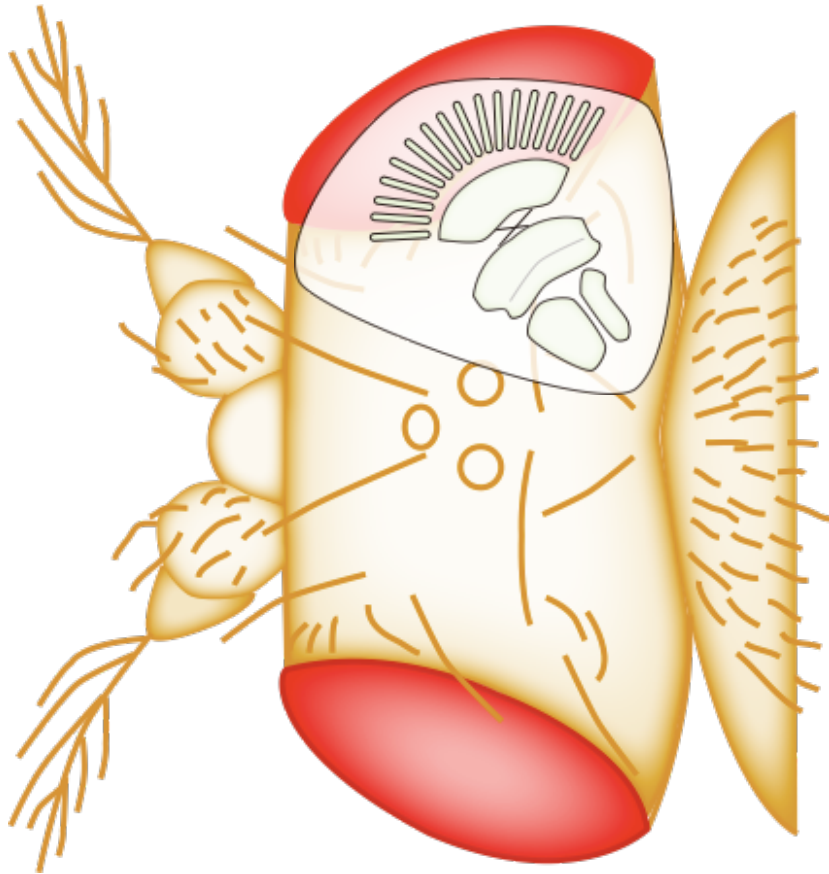
+ Lamina, L1-L5, T1, C2-C3 (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



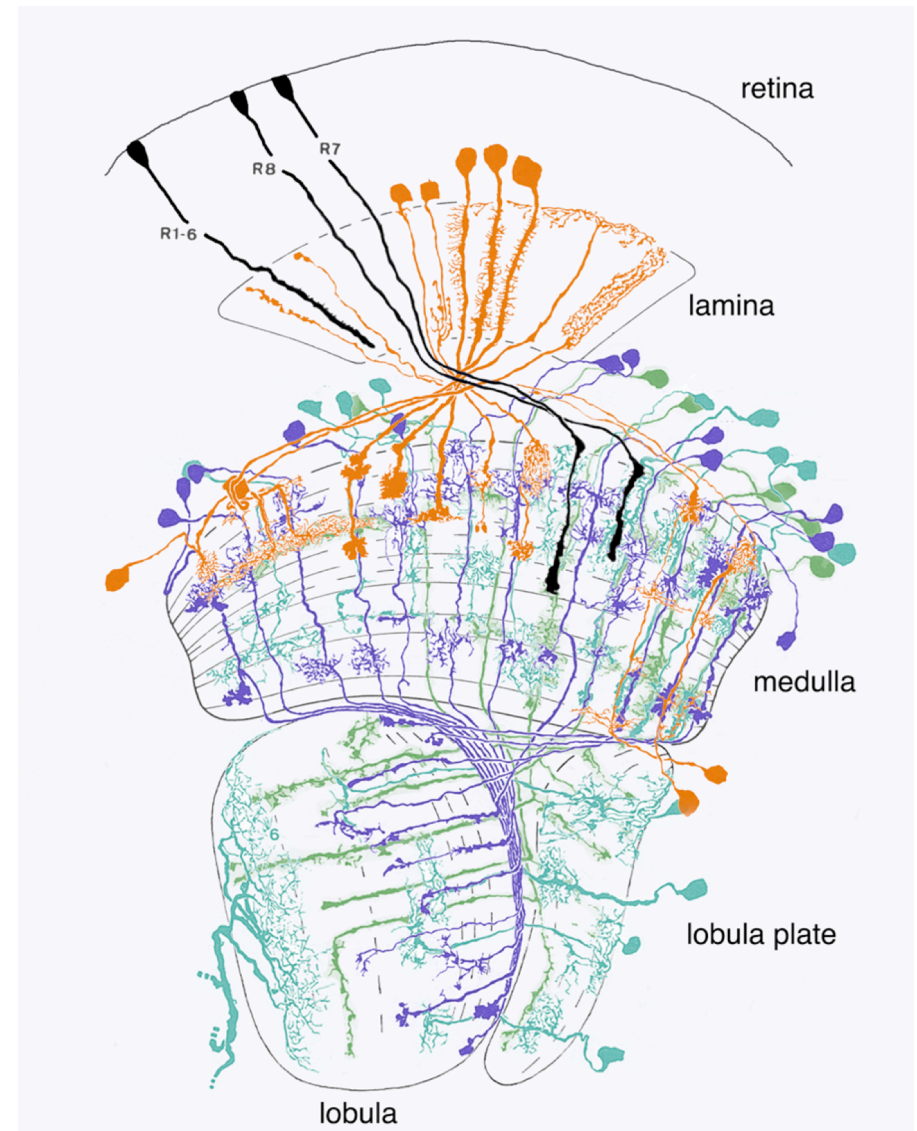
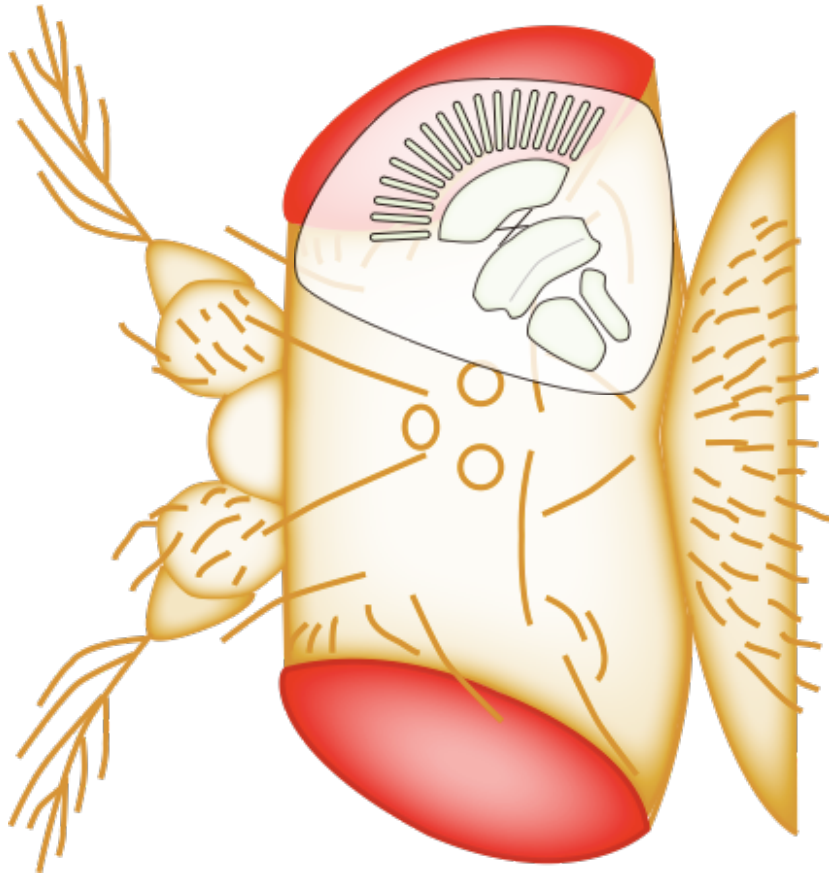
+ Transmedulla (Tm) neurons (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



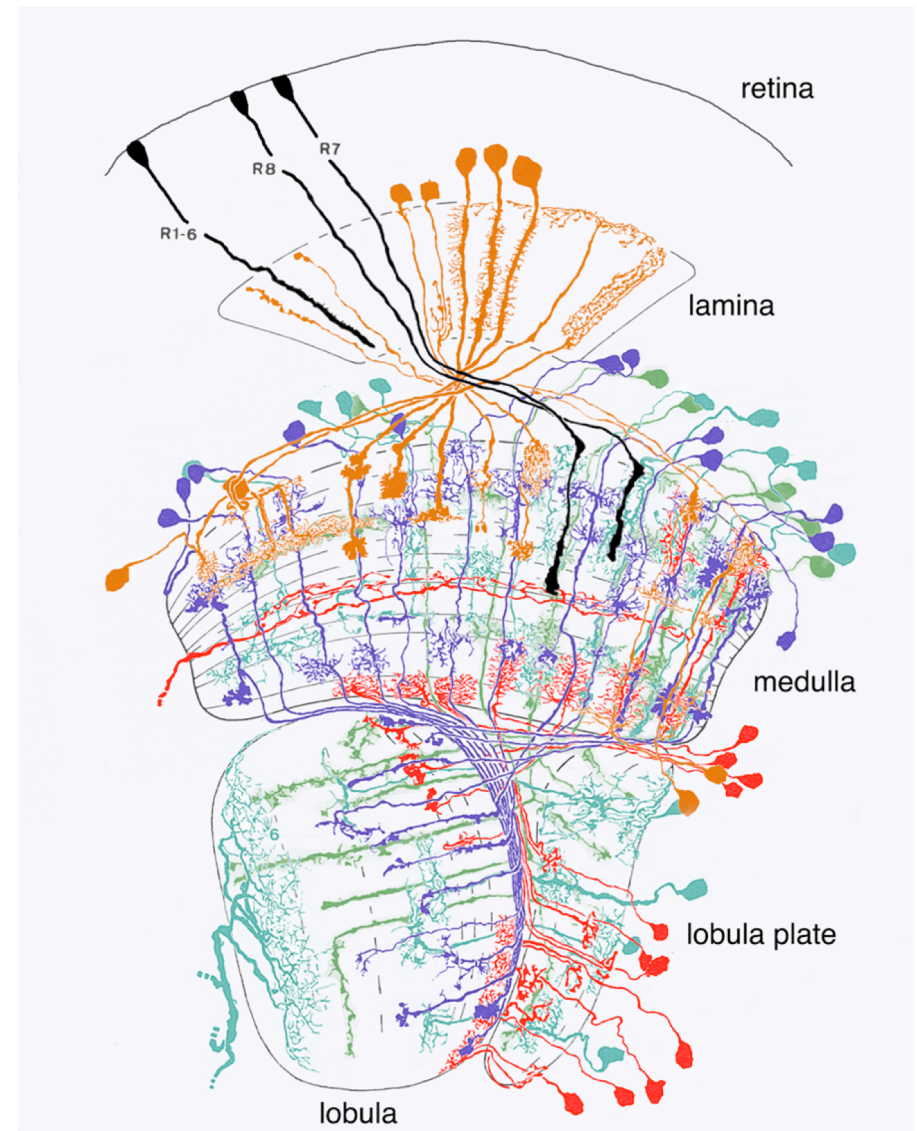
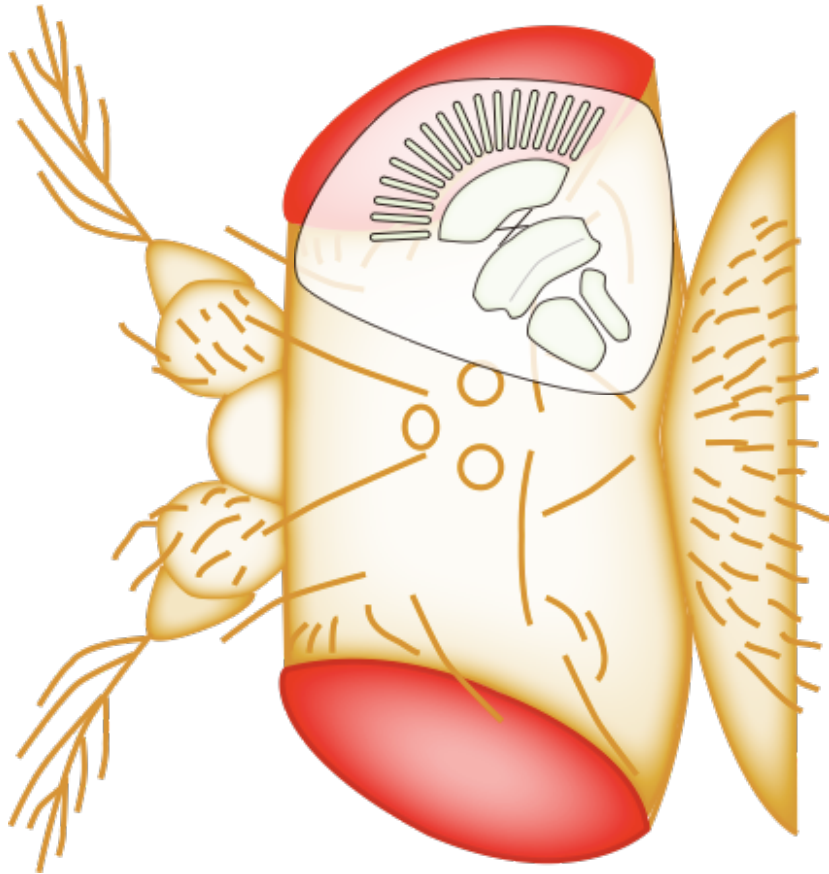
+ Mi cells, Tlp cells (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



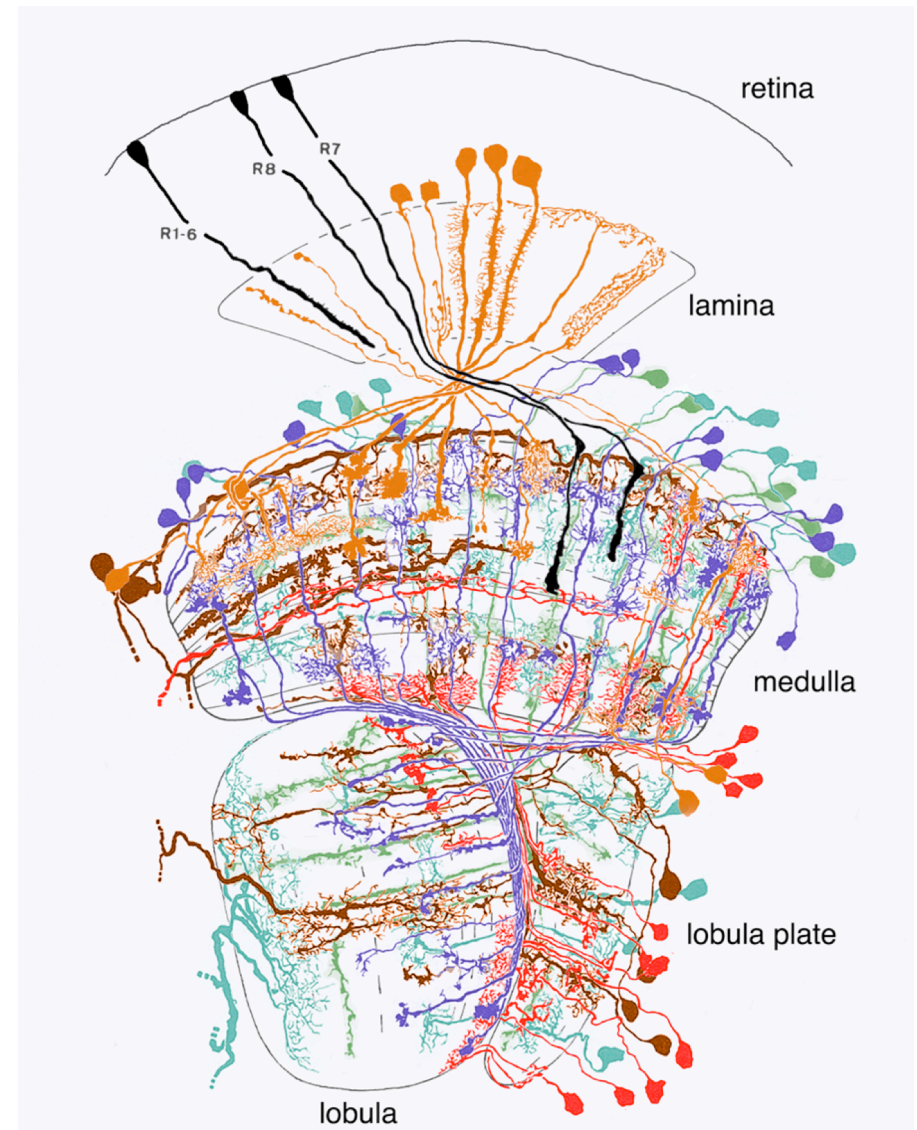
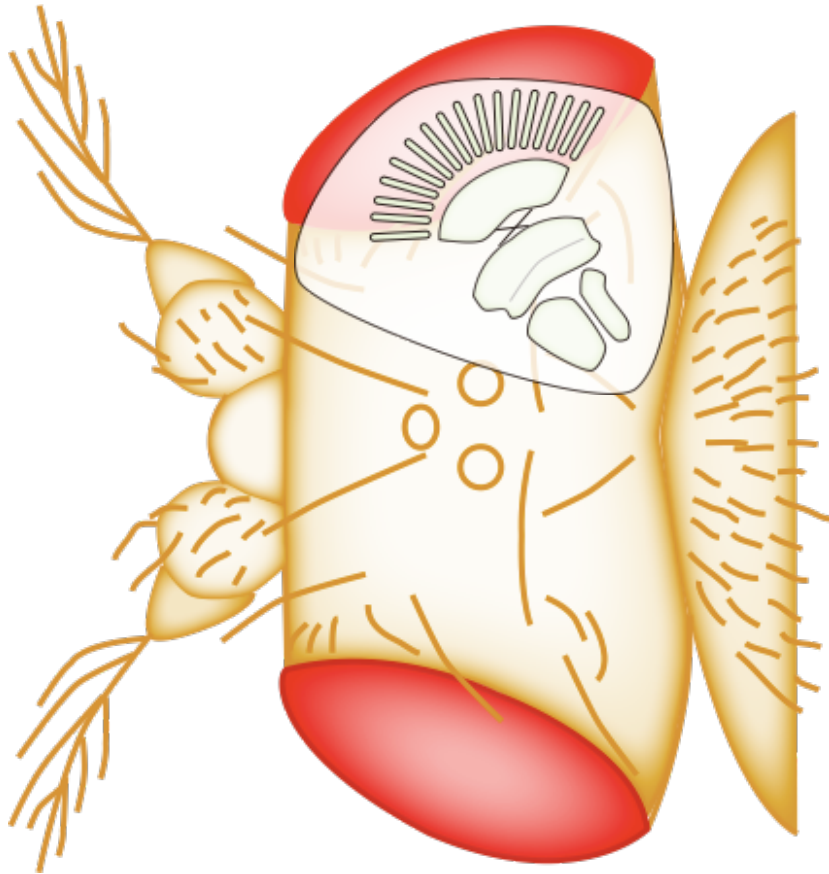
+ TmY cells (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



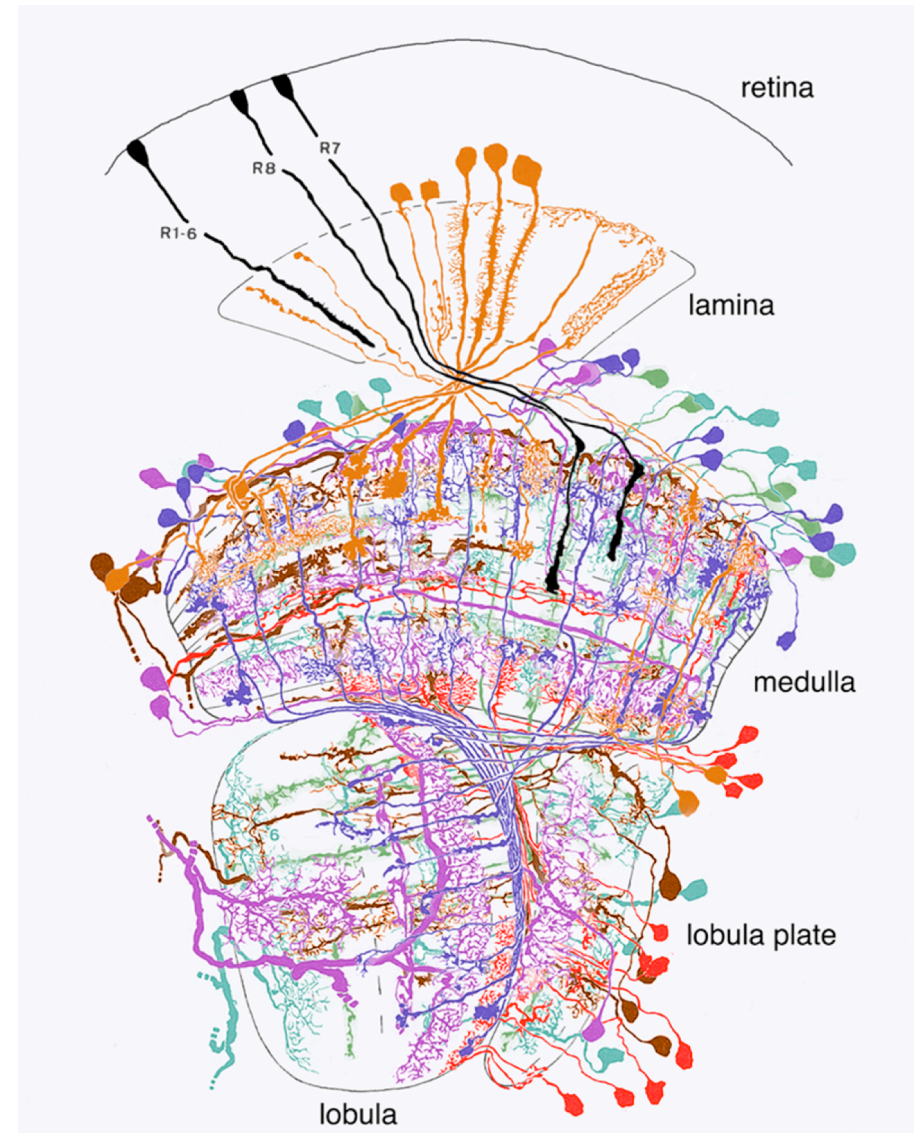
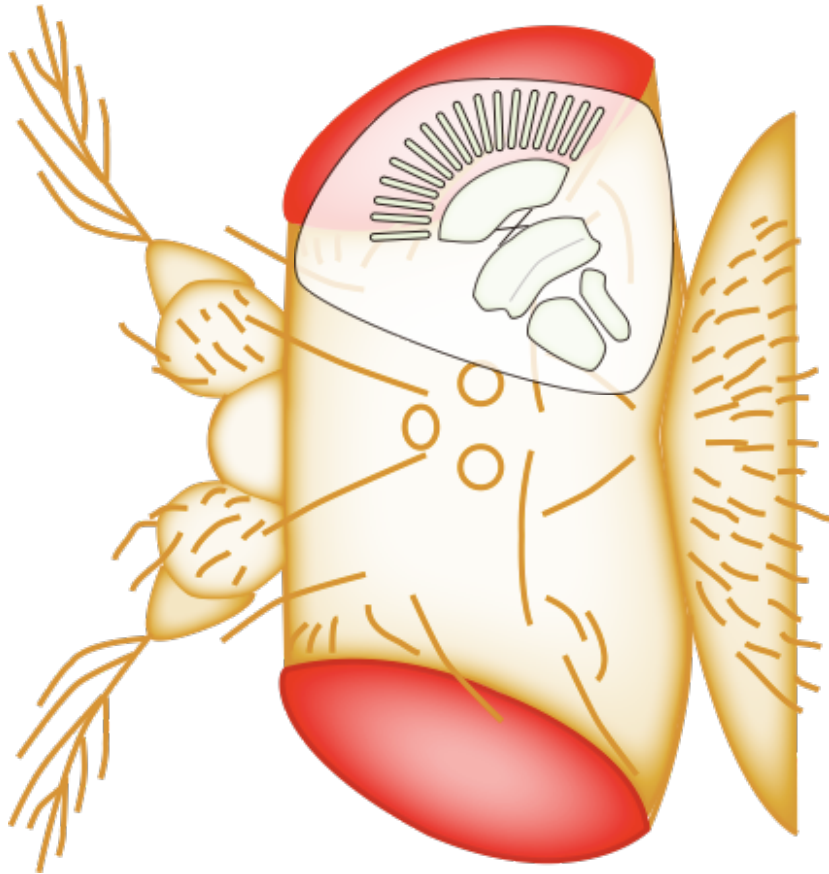
+ T-cells (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



+ Y cells, Mt cells (Fischbach & Dittrich, 1989)

Visual system of *Drosophila*



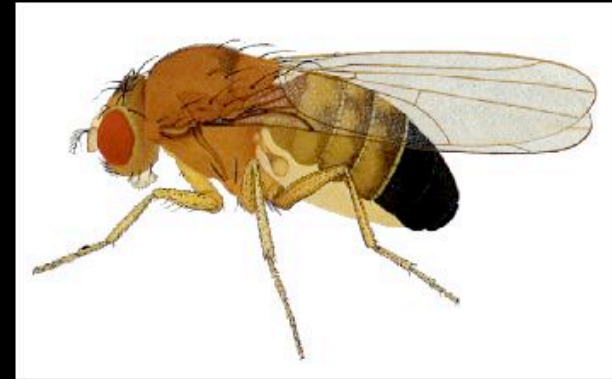
+ Amacrine, Dm, Pm, Lt cells (Fischbach & Dittrich, 1989)

Gal4-UAS systeme in *Drosophila*



Gal4 driver

×



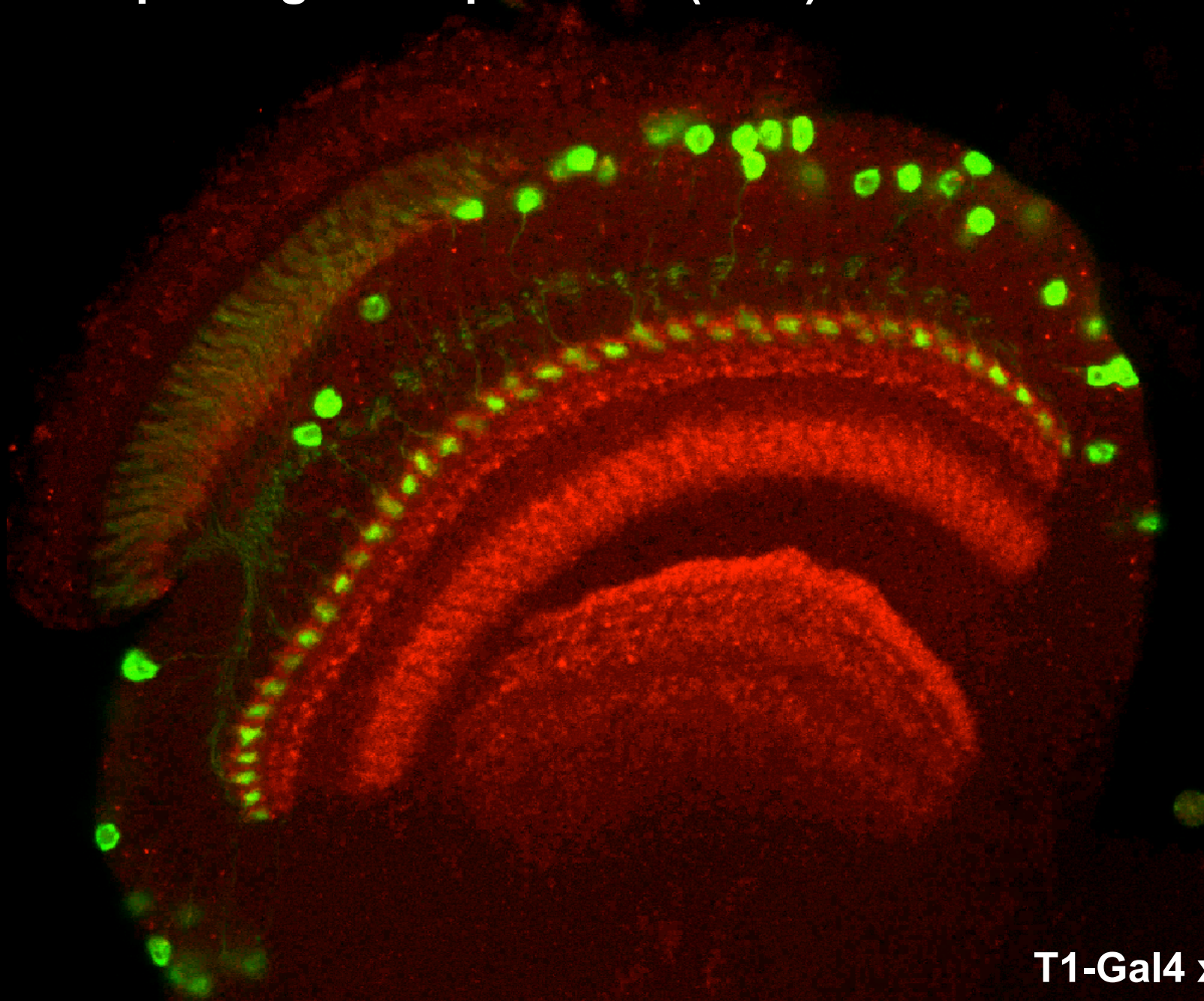
UAS line



Brand und Perrimon, 1993

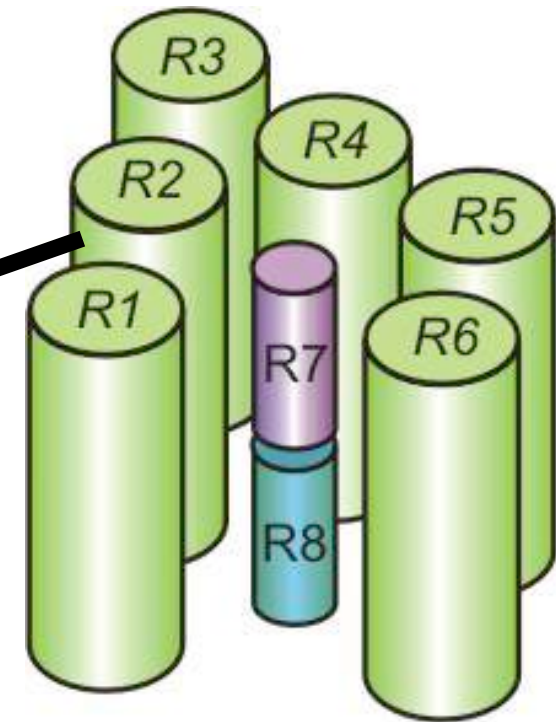
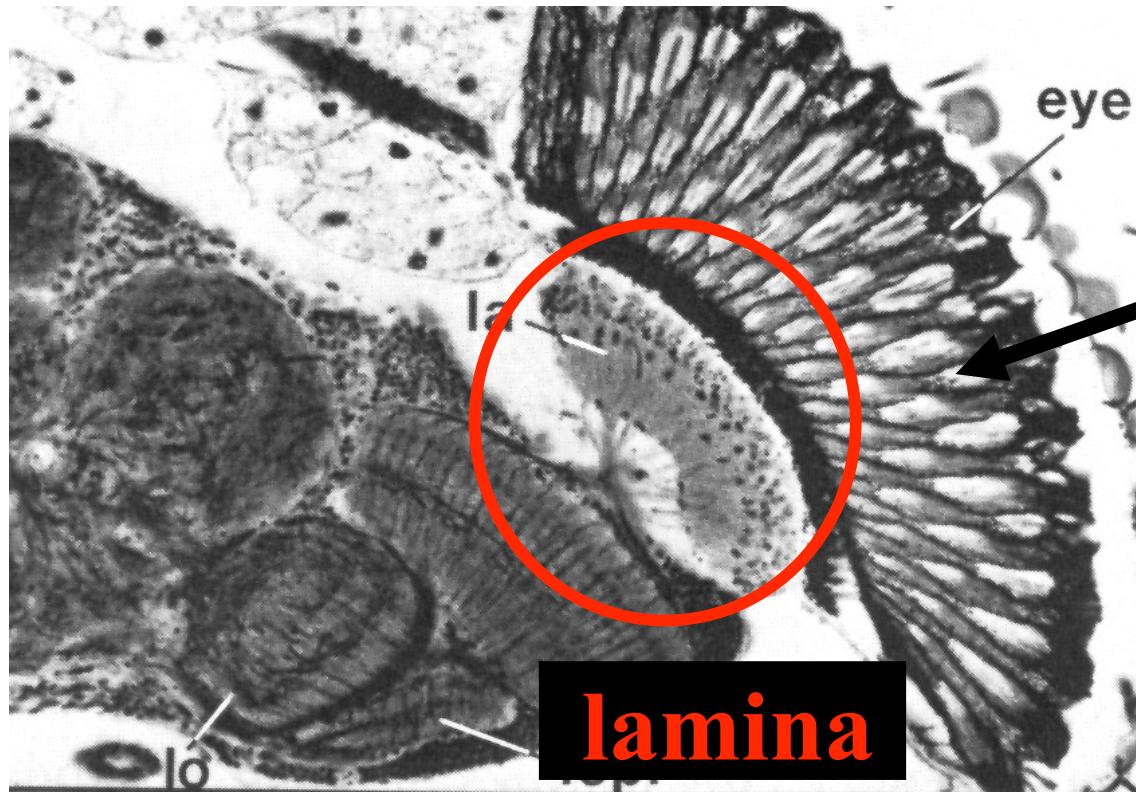
example:

Reportergene expression (GFP) in all T1-neurons



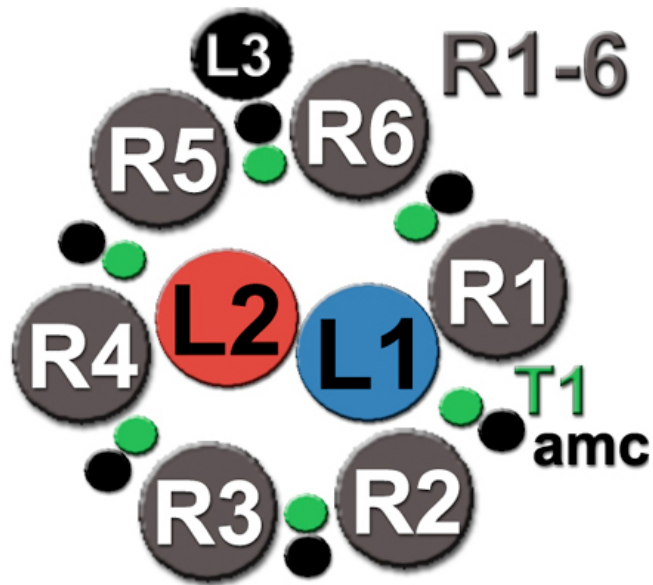
T1-Gal4 x UAS-gfp

The visual system of *Drosophila*

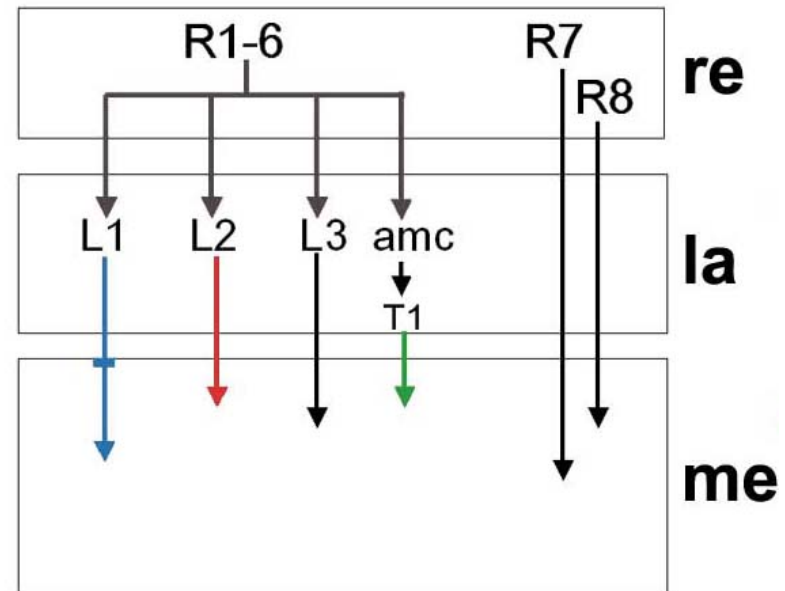


three types of
receptors

Parallel pathways at the level of the lamina



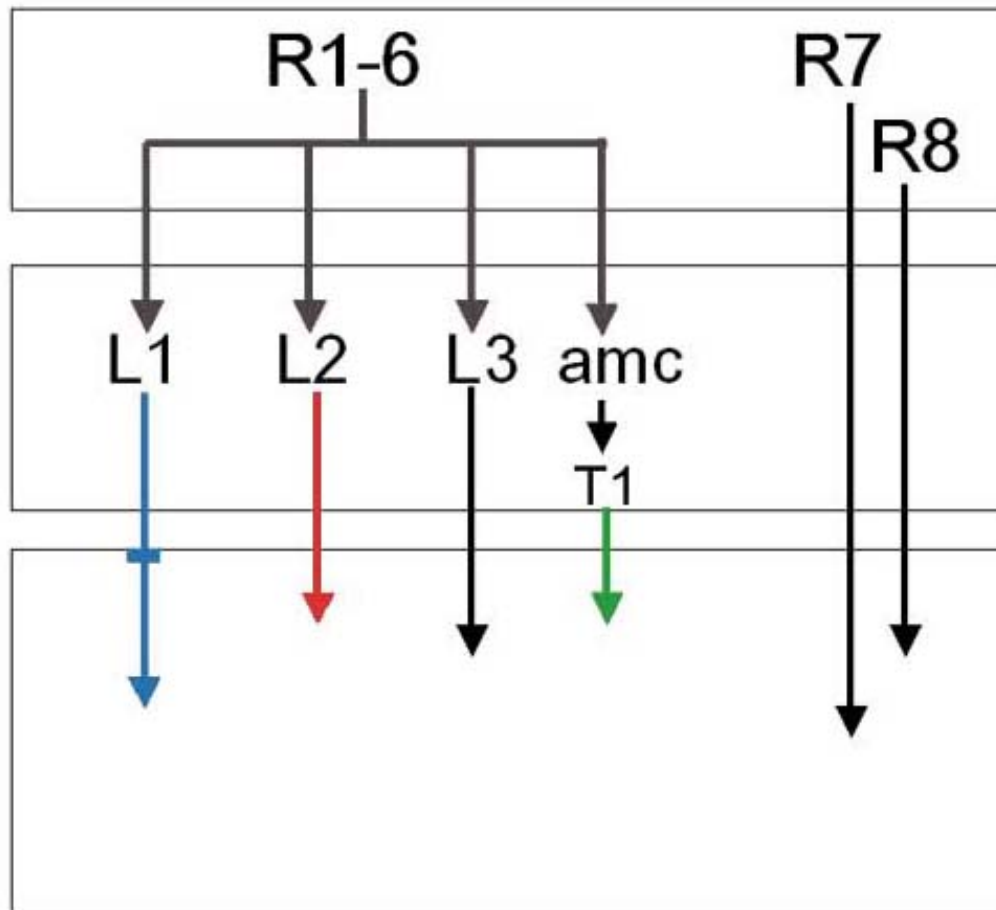
Lamina Cartridge



parallele Funktionswege

What is there function?

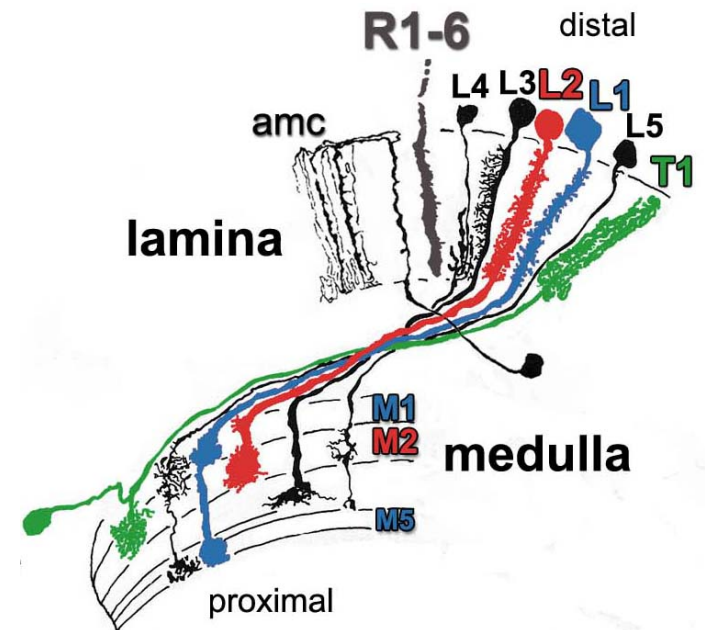
Which pathways are important for motion detection?



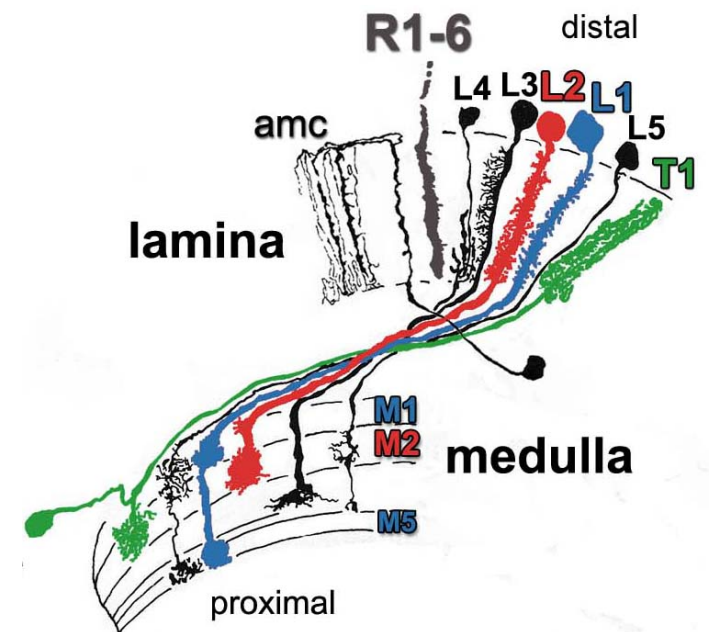
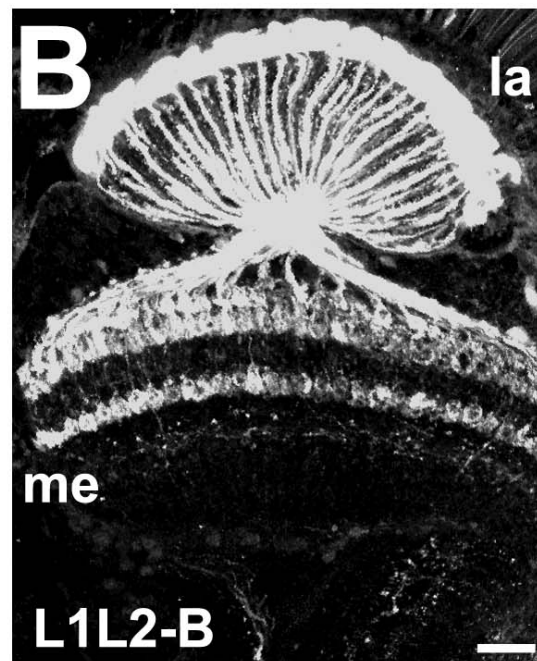
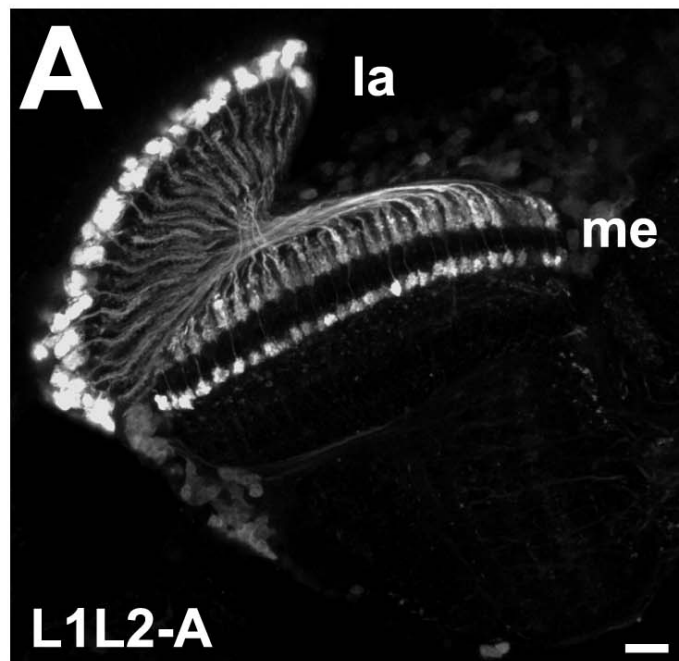
re

la

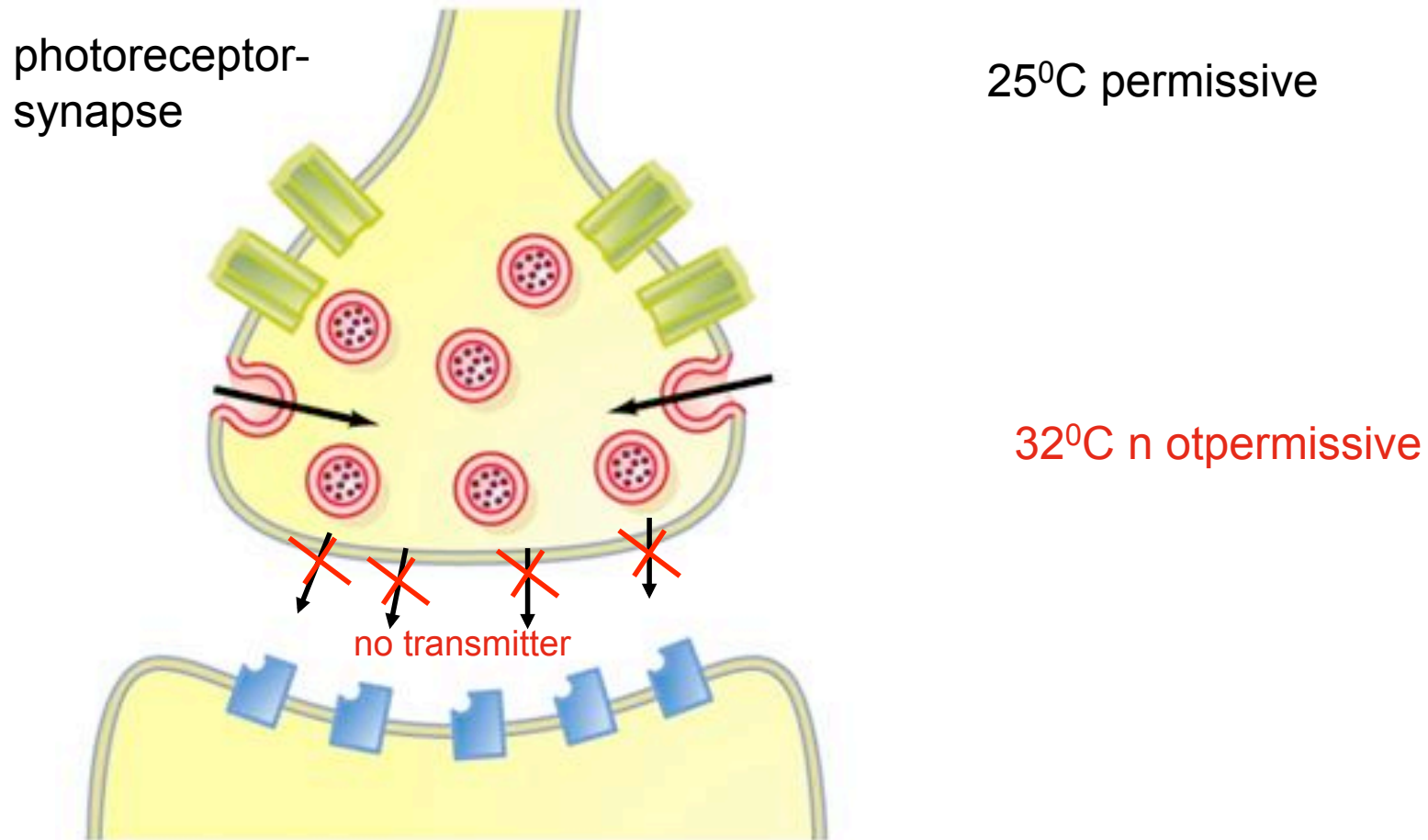
me



Gal4-drivers for **L1** and **L2**

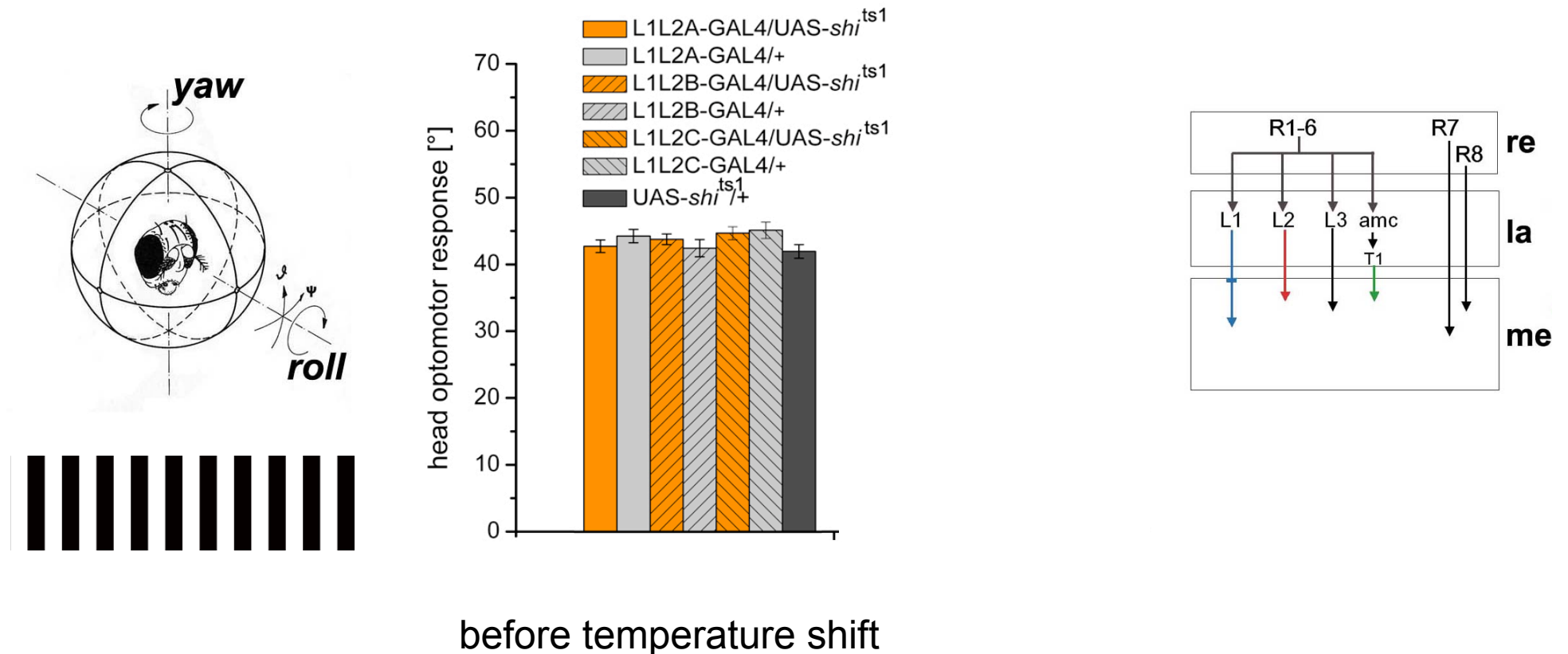


***shi^{ts}* is a temperature-sensitive dynamin mutant**



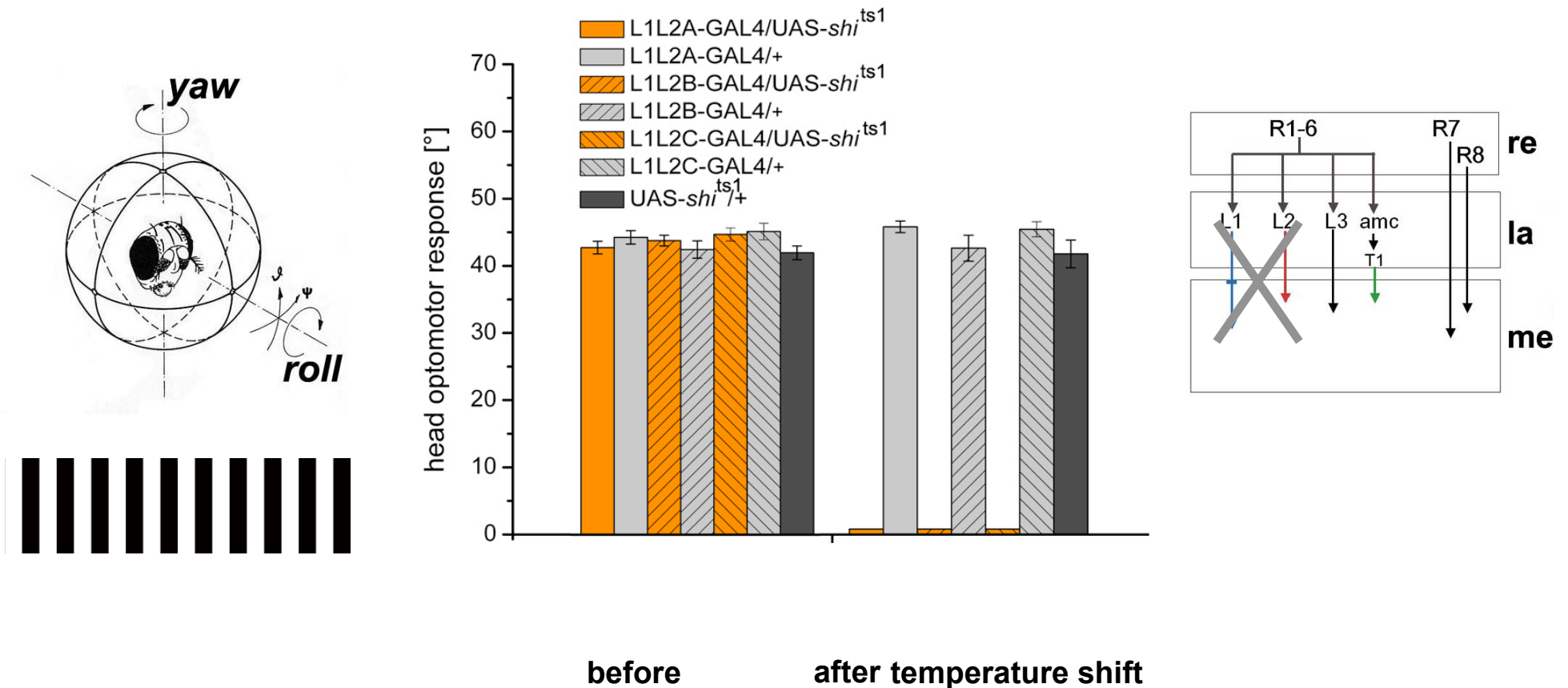
1. strategy: Cross Gal4-driver line with UAS-*shi^{ts}*

L1 and L2 are required for optomotor response



Data from Rister et al., 2007

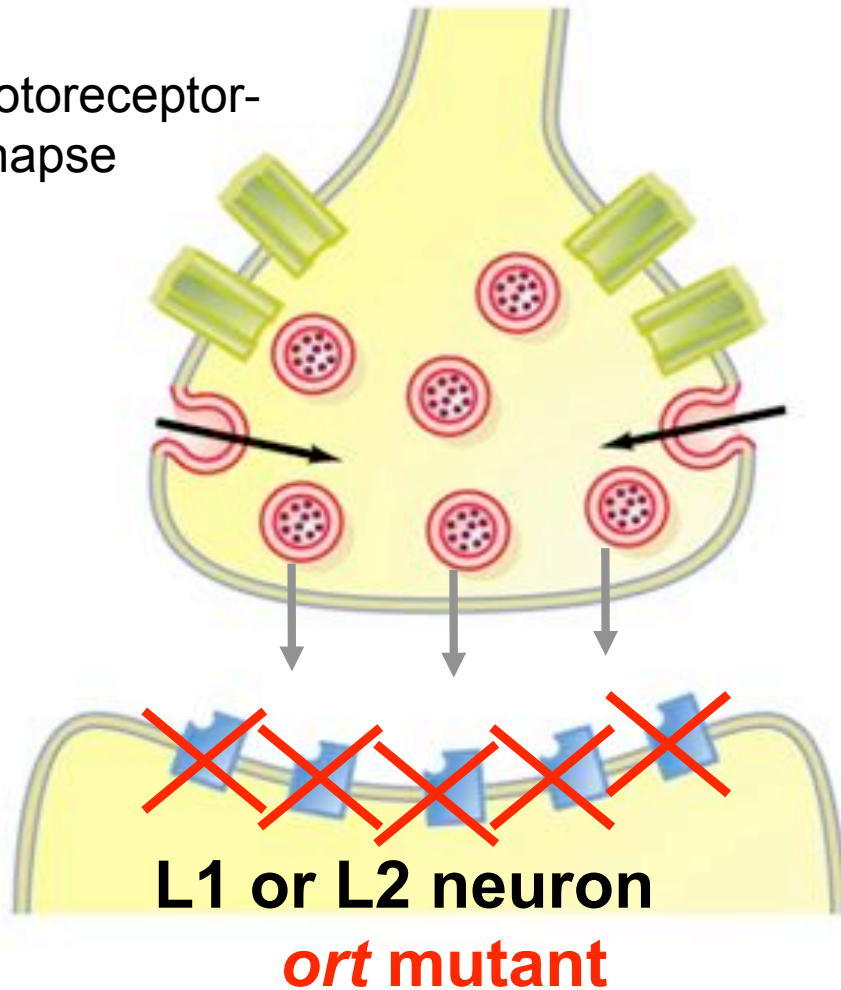
L1 and L2 are required for the optomotor response



data from Rister et al., 2007

Strategy 2: Rescue of function: Restore histamin receptors in defined cells

Photoreceptor-
synapse

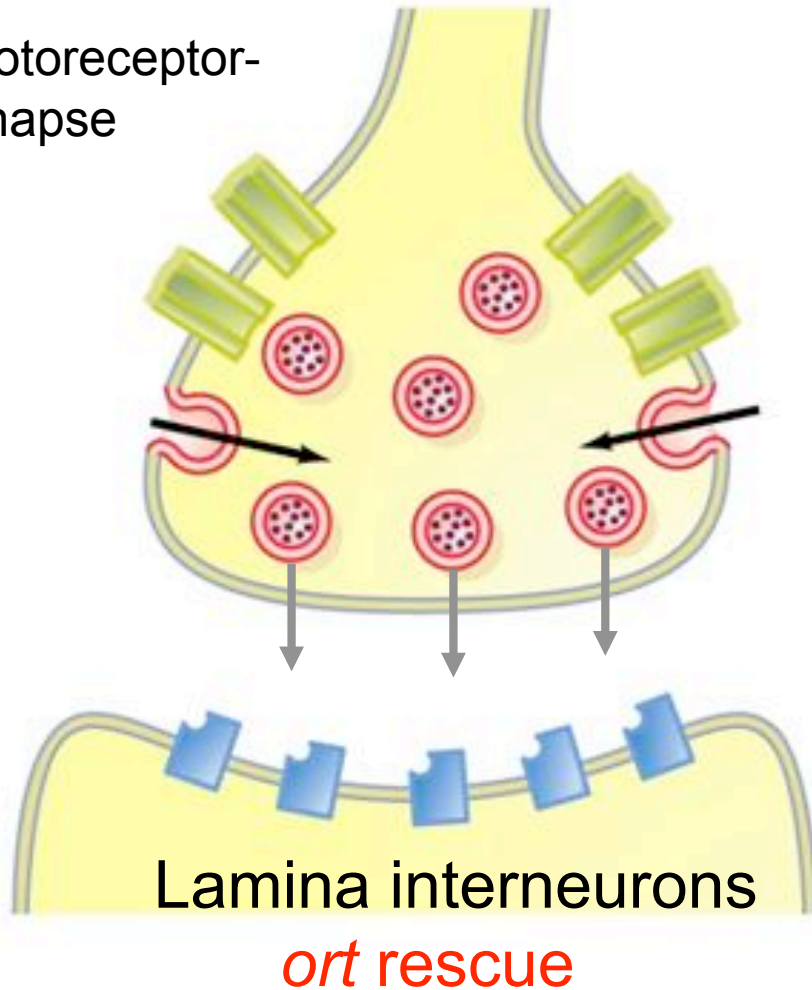


Histamin is the transmitter
of photoreceptors

In *ort* mutants the histamin
receptors are defective

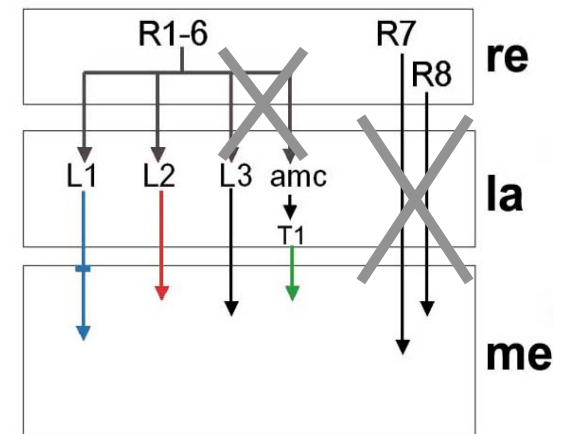
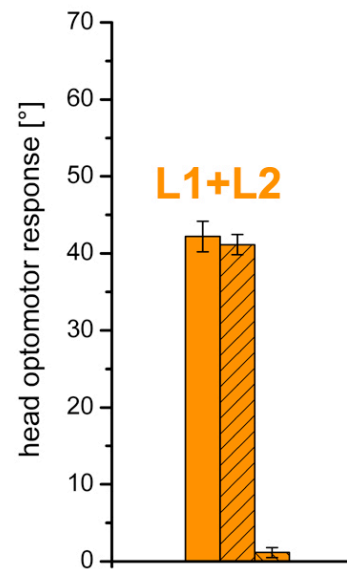
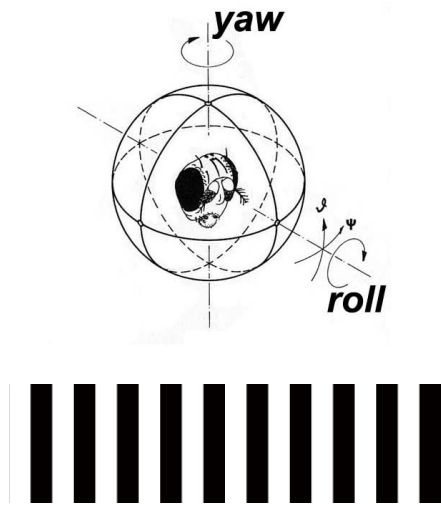
Is it sufficient to restore histamin receptor function in **L1** and **L2** neurons in *ort* mutants for motion detection?

Photoreceptor-synapse



Expression of UAS-*ort* in lamina interneurons rescues histamin receptor function in those neurons

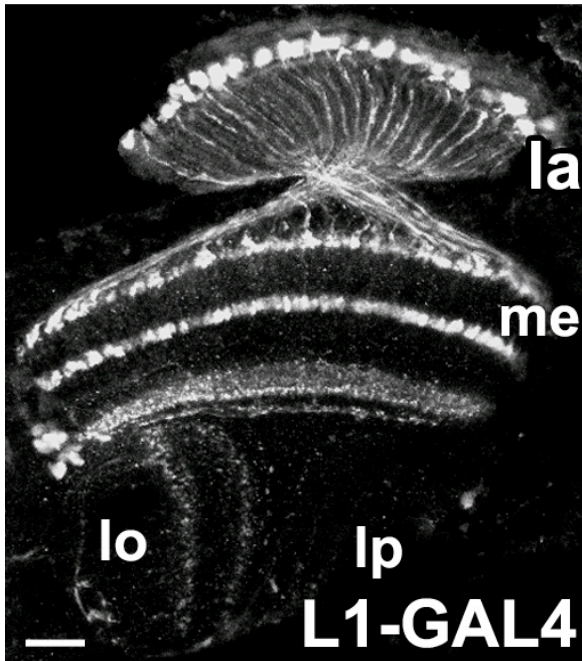
L1 and L2 are sufficient for motion detection



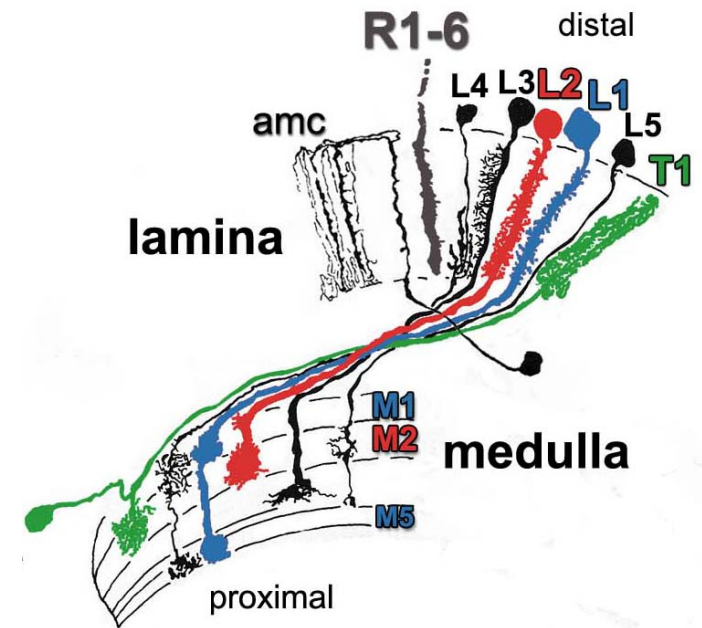
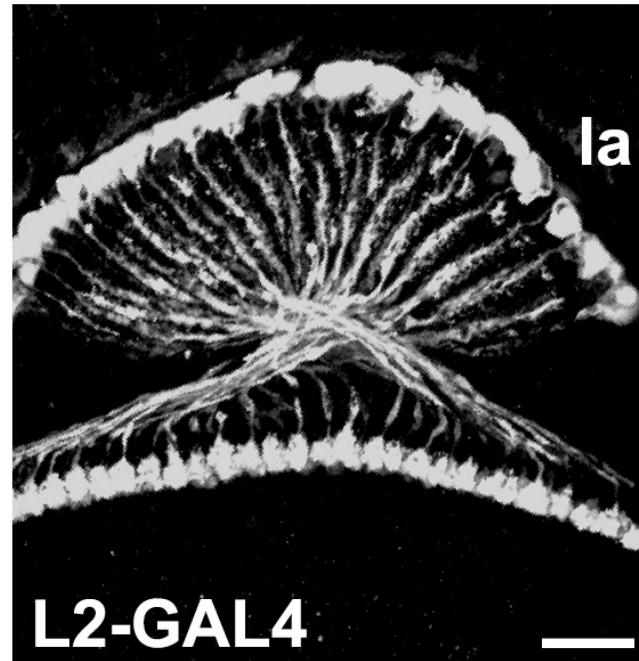
data from Rister et al., 2007

specific GAL4-drivers for either L1 or L2

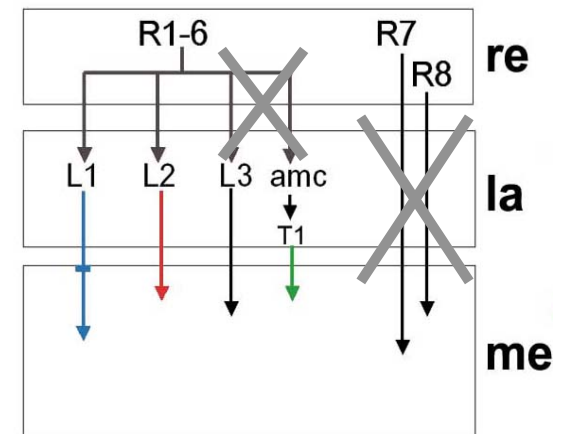
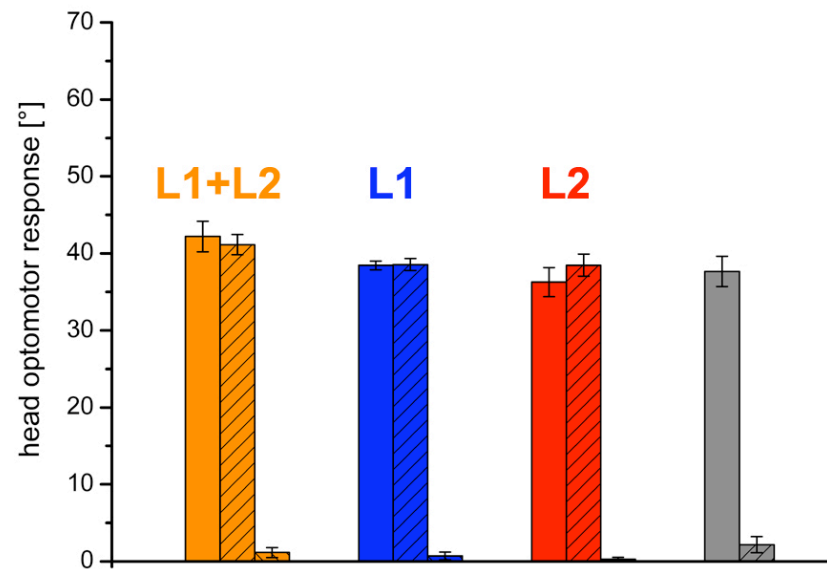
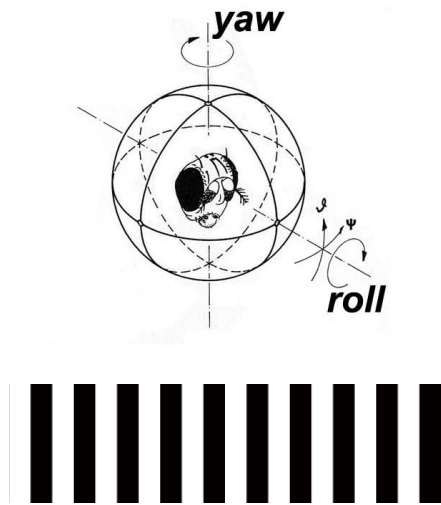
L1



L2

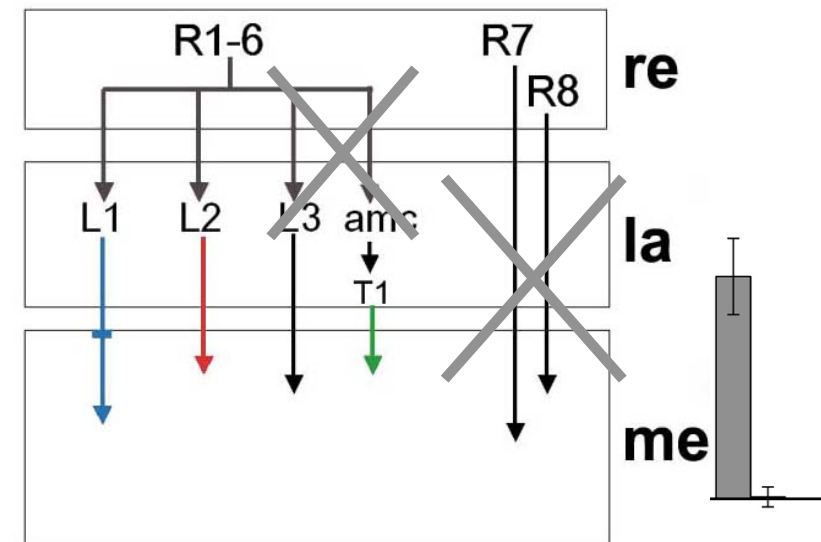
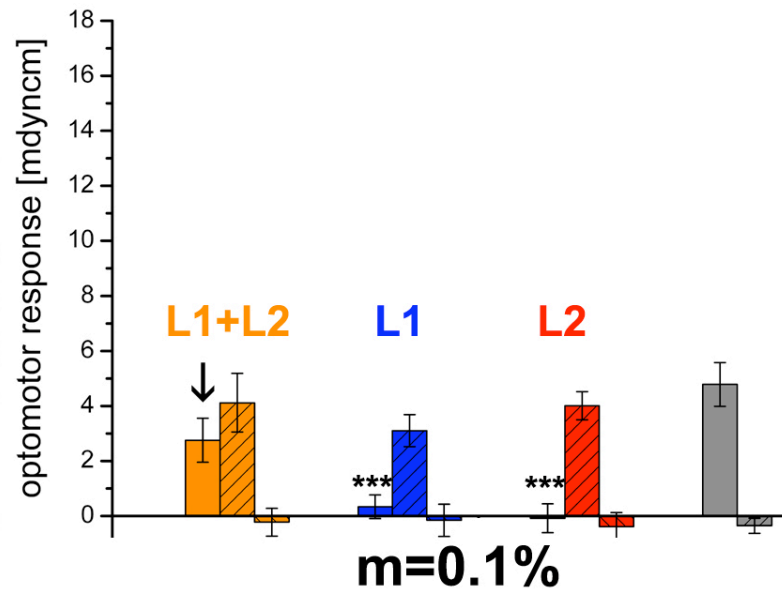
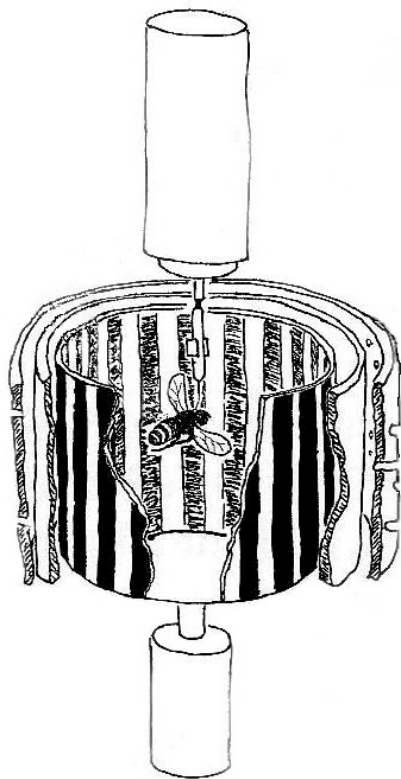


L1 and L2 channels are both alone sufficient for motion detection



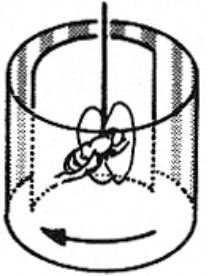
data from Rister et al., 2007

L1 and L2 are both together required at low pattern contrast

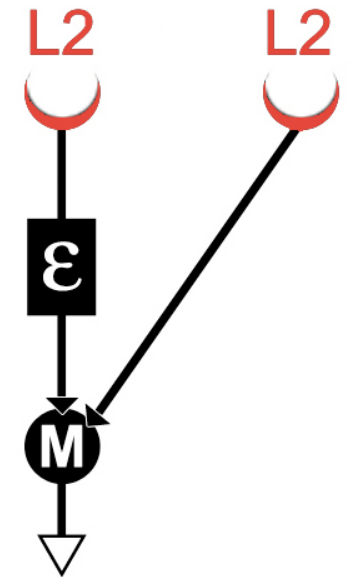
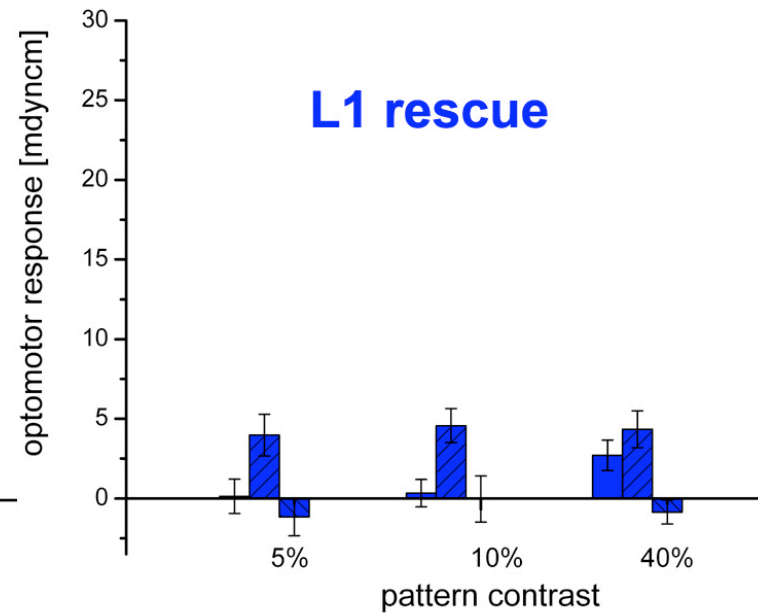
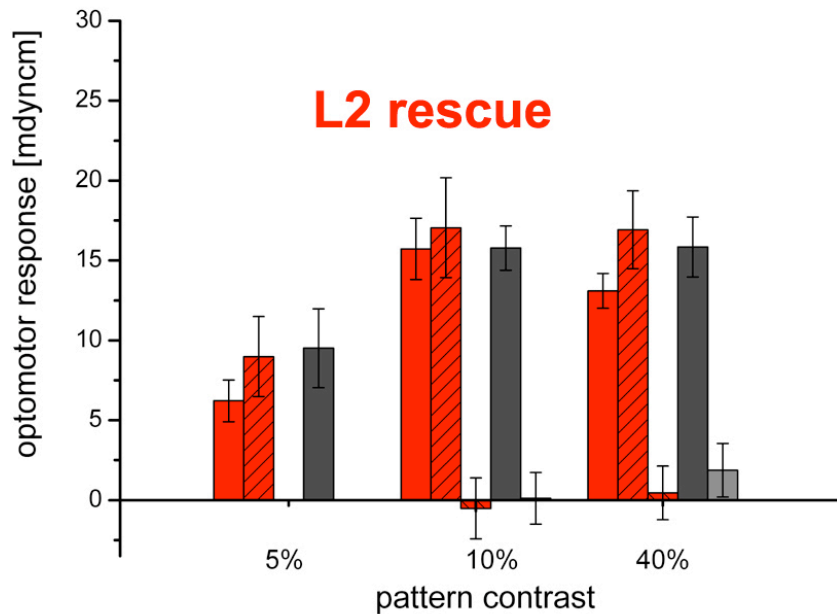


data from Rister et al., 2007

At medium pattern contrast:
the **L2** pathway is responsible for
front-to-back motion

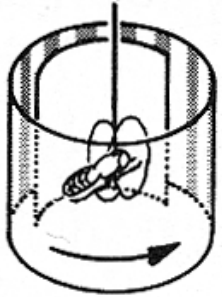


front to back motion

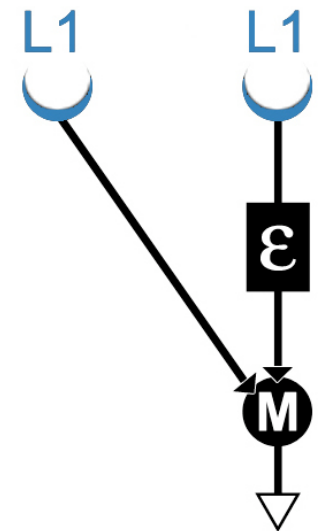
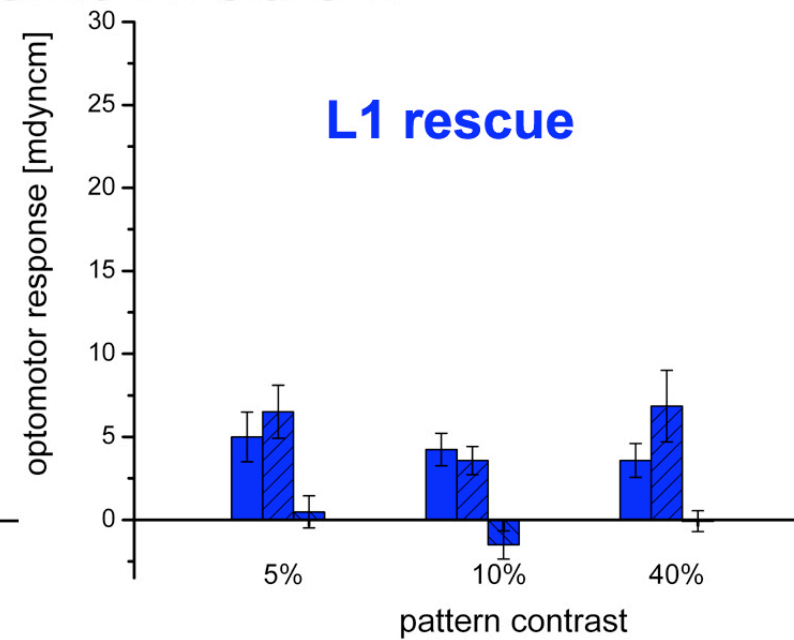
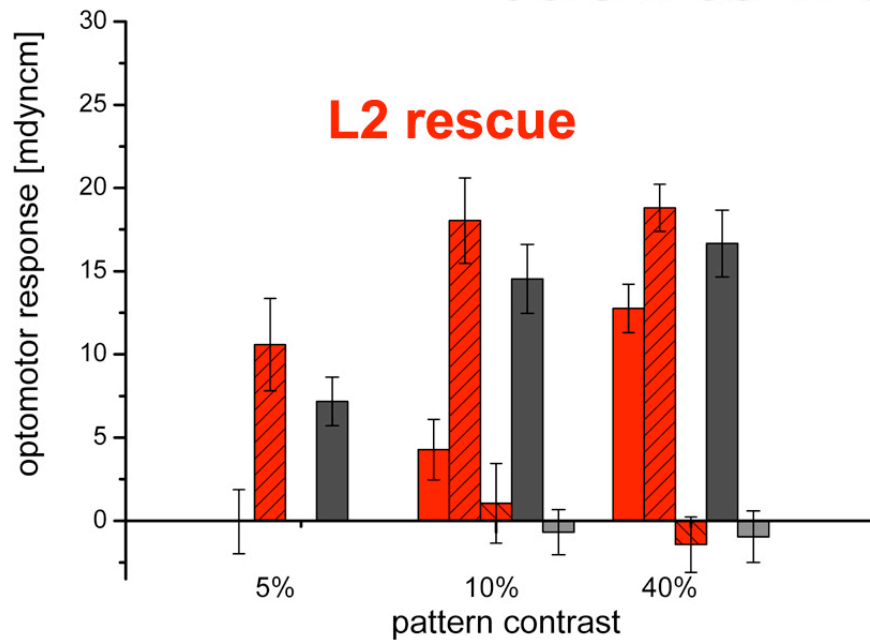


data from Rister et al., 2007

At medium pattern contrast:
The **L1** pathway is responsible for
back-to-front motion

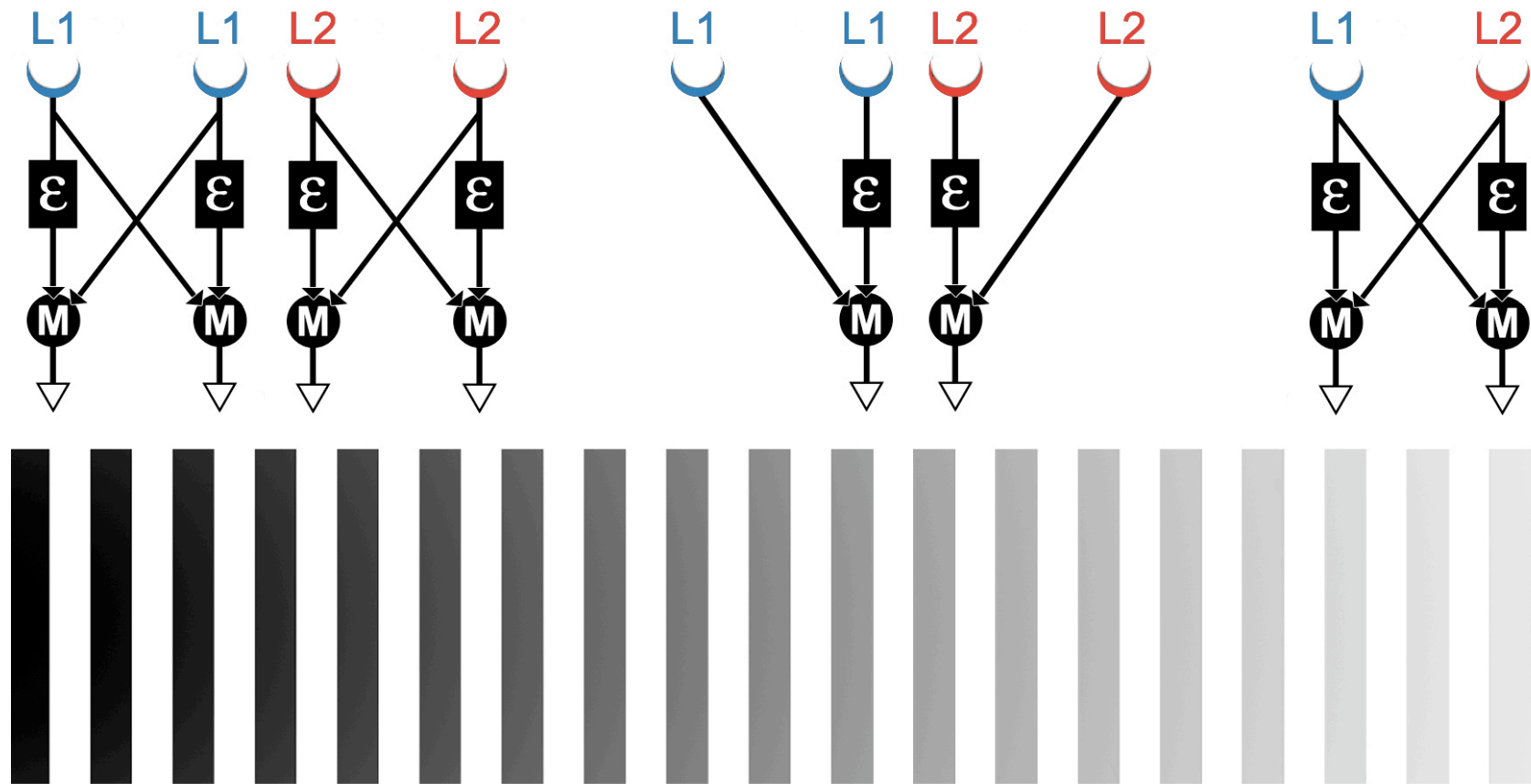


back to front motion



data from Rister et al., 2007

Summary



L1 and L2 pathways are important for motion detection. Depending on the contrast they are sufficient as input into both directional EMDs, they specialize or they co-operate.

thank you!!

