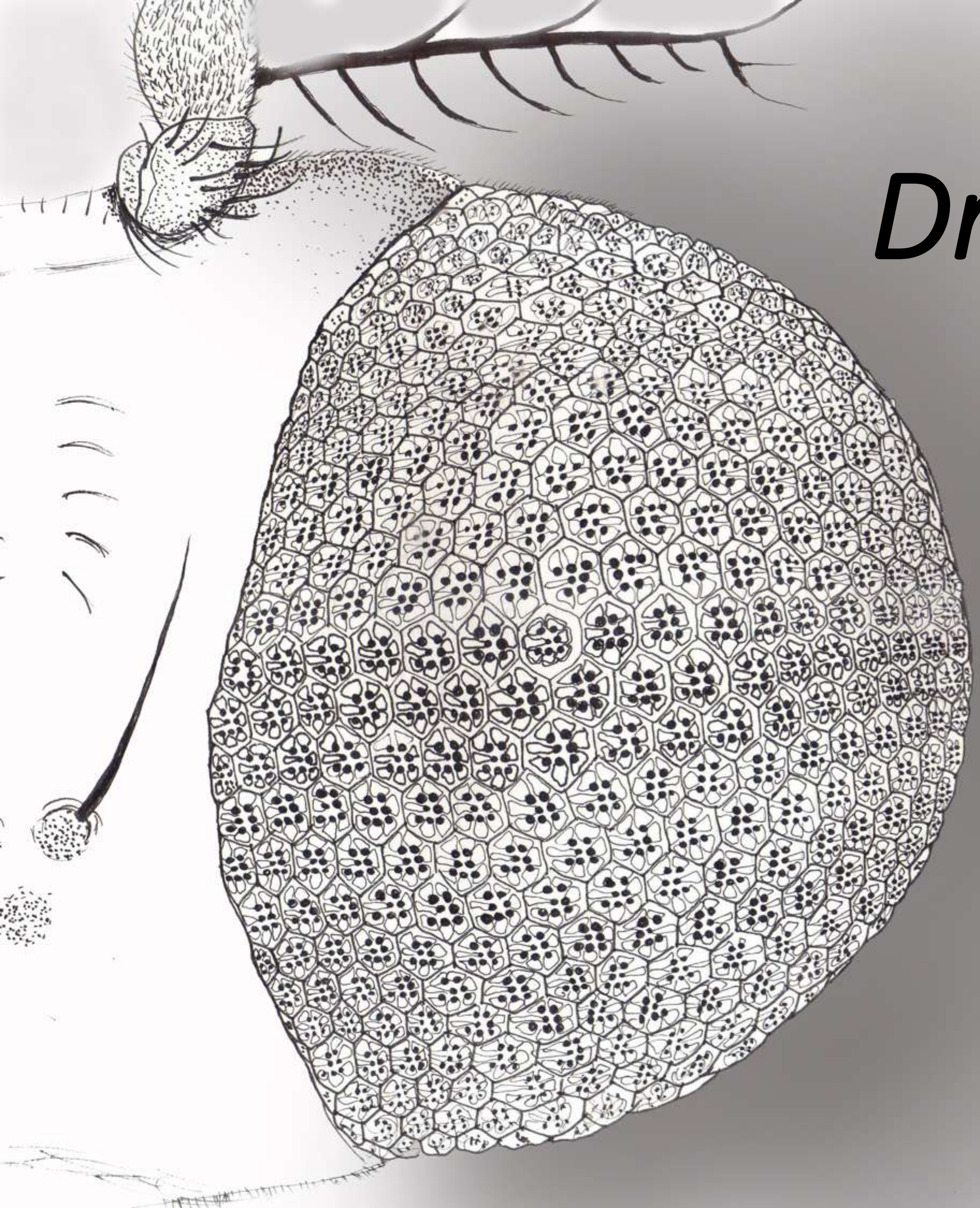
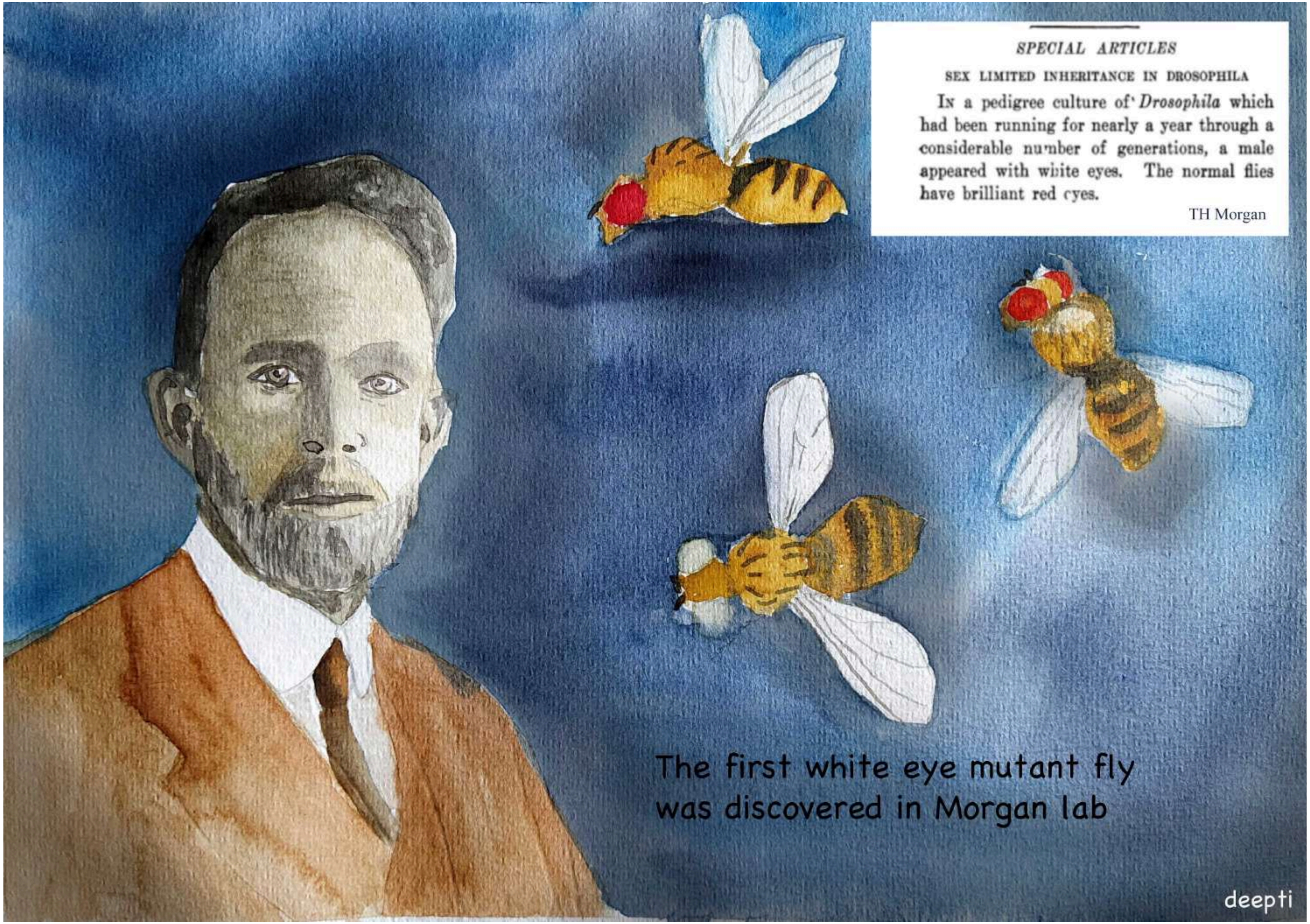


Drosophila at a glance

Using flies to understand ourselves better

By Deepti Trivedi



The white gene:

The 1st white eyed mutant was isolated in **Morgan** lab (see inset for 1st sentence of his paper).

Crossing this with wildtype flies and then other mutants led to the hypothesis that genes are physical entities located on chromosomes.

A spontaneous mutation at the beginning of the 1900s resulted in the birth of Drosophila genetics.

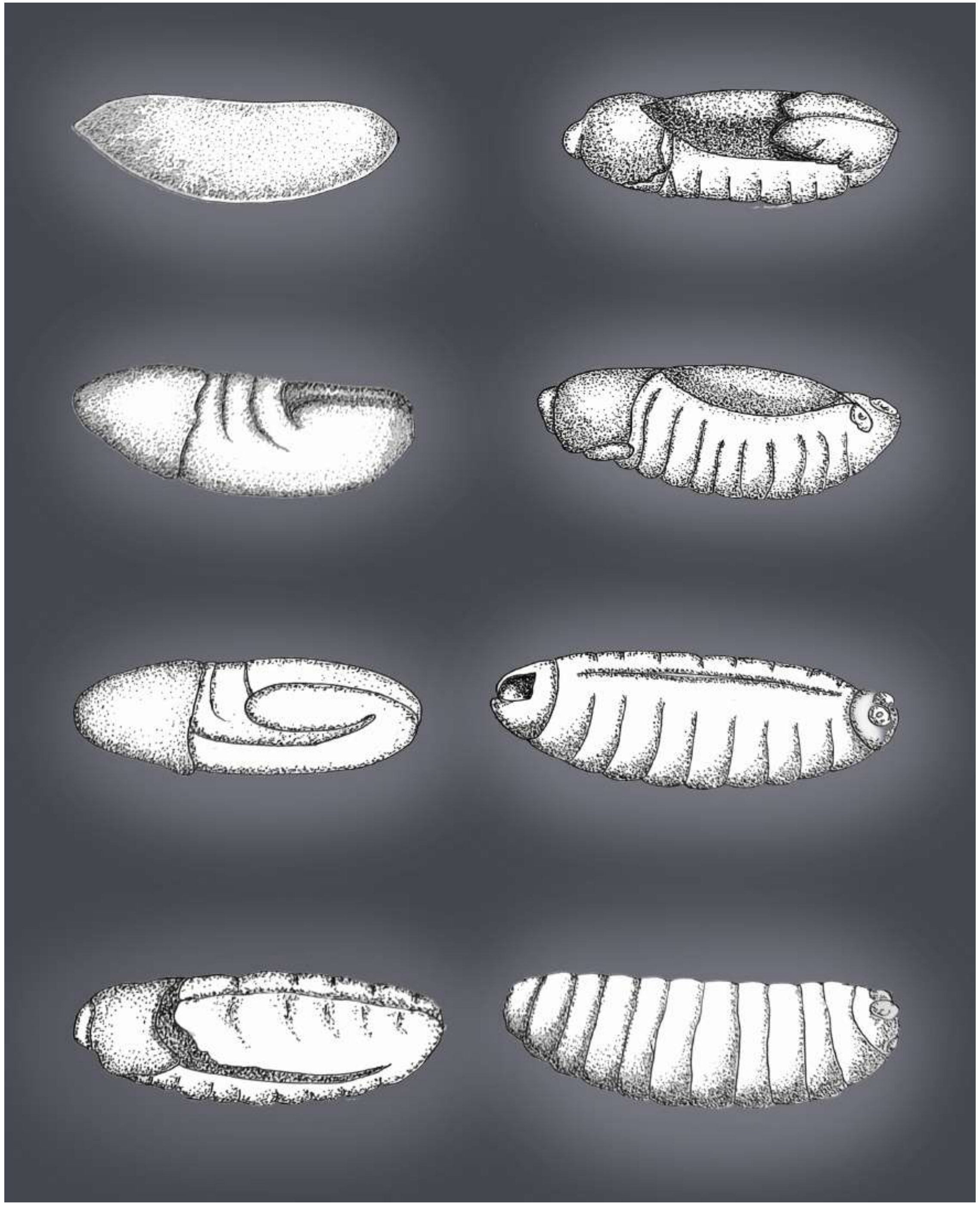
Polytene chromosomes

Polytene chromosomes are
large chromosomes which have thousands of DNA strands. They provide a high level of function in certain tissues such as salivary glands of insects.

Polytene chromosomes, at interphase, are seen to have distinct thick and thin banding patterns.

In 1935, Hermann J. Muller and A.A. Prokofyeva established that the individual band or part of a band corresponds with a gene in *Drosophila*.

Muller received a Nobel Prize in medicine in 1946 for the discovery of the production of mutations by means of X-ray irradiation.



Development

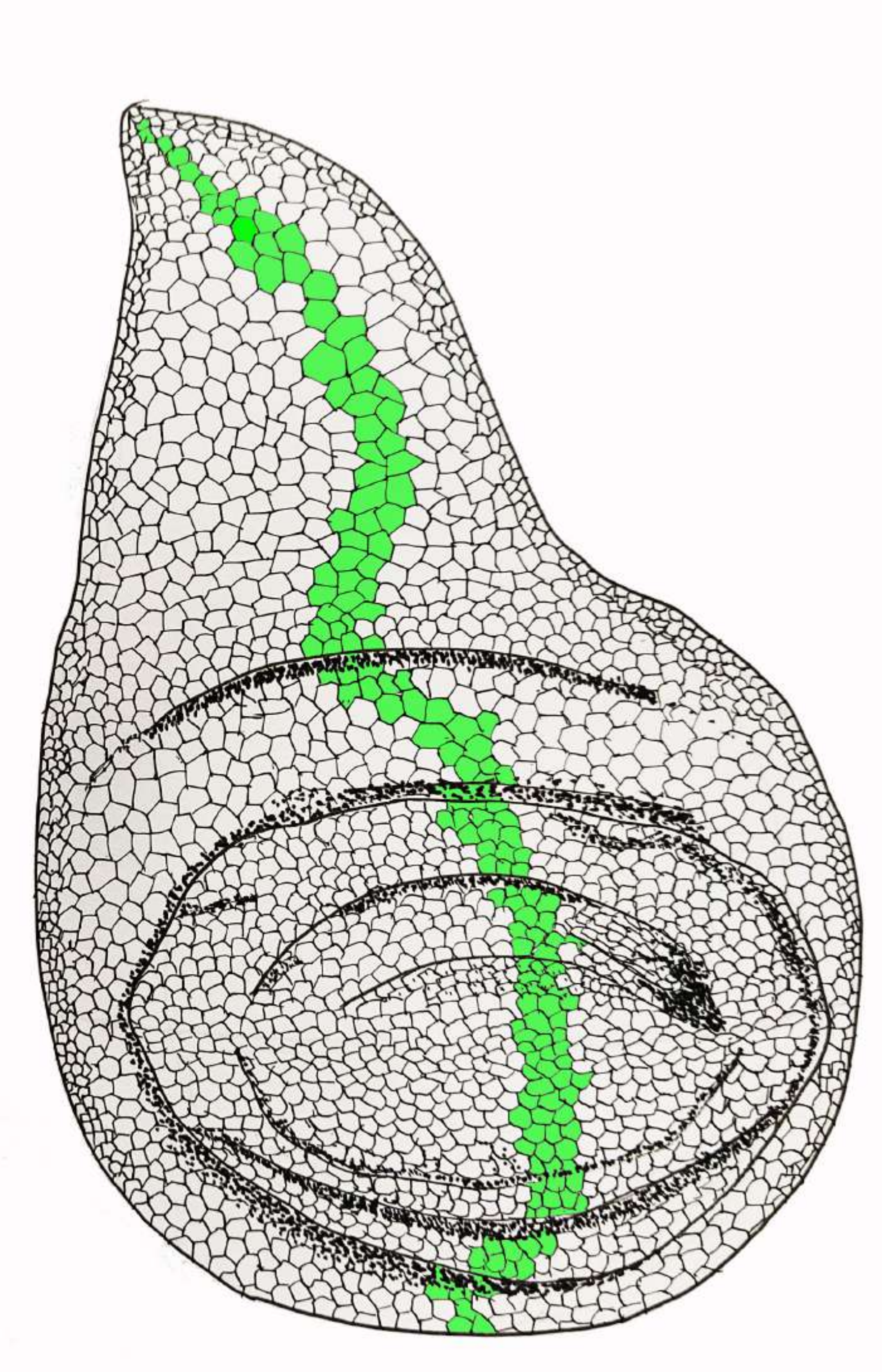
Study of *Drosophila* development, which can be divided into embryonic development, larval metamorphosis and adult development has shed a lot of light on genetic basis of development across metazoans.

Mutagenesis is easy to perform and large scale phenotypes are easy to score, making it a sought after model organism.

Using a forward genetic screen performed by **Edward B. Lewis, Christiane Nüsslein-Volhard** and **Eric F. Wieschaus** identifed and classified a small number of genes that are of key importance in determining the body plan and the formation of body segments.

They received a Nobel prize in medicine for this discovery in 1995

The principles found in the fruit fly, apply also to higher organisms including humans.



Imaginal discs

An imaginal disc is a sac-like epithelial structure found inside the larva of insects that undergo metamorphosis. Once the larva turns into a pupa, almost all the larval tissues degenerate and the imaginal discs turn into the external structures of the head, thorax, limbs and genitalia.

The reason imaginal discs are of such interest to developmental biologists is that they provide a powerful system to study multiple aspects of development and biological mechanisms underlying disease; they are one of the reasons that make the fruit fly Drosophila melanogaster an excellent model organism.

There are a total of 19 imaginal discs in flies.

Here is an artistic expression of Protein **Patched** in a wing disc.

Some of the sentences are taken from Aldaz S and Escudero LM, Current biology

Circadian rhythms

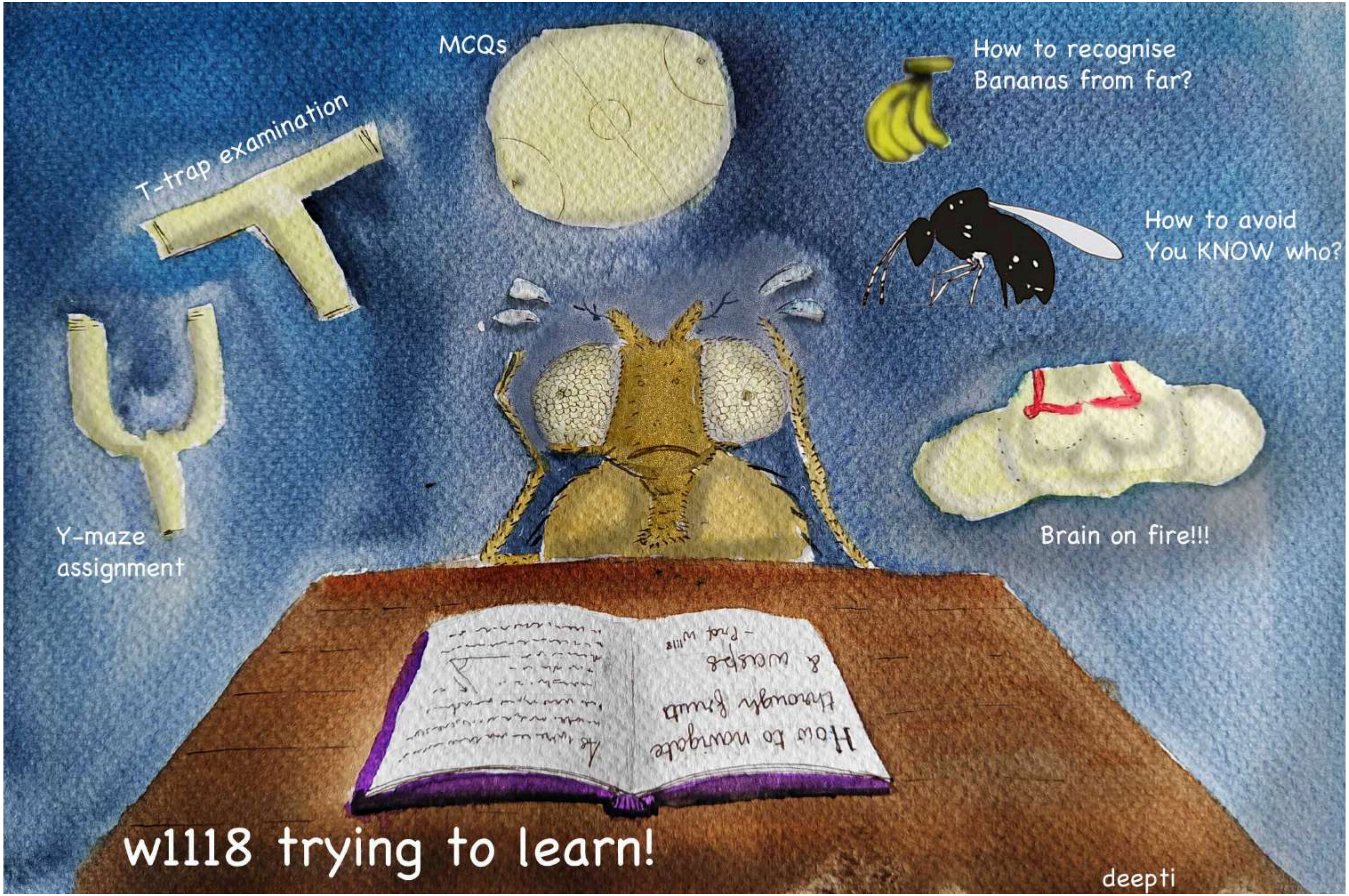
Drosophila circadian rhythm is a daily 24 hours cycle of rest and activity.

In 1971, Seymour Benzer and Ronald J. Konopka reported that mutation in specific genes changes or stops the circadian behaviour. The first gene discovered was called *period* (*per*), mutation in which alter the circadian rhythm. It was the first gene known to control any behaviour.

After a decade, Konopka, Jeffrey C. Hall, Michael Rosbash, and Michael W. Young discovered novel genes including *timeless* (*tim*), *Clock* (*Clk*), *cycle* (*cyc*), *cry*. These genes and their product proteins play a key role in the circadian clock.

Hall, Rosbash and Young received a Nobel prize in medicine for their pioneering work.

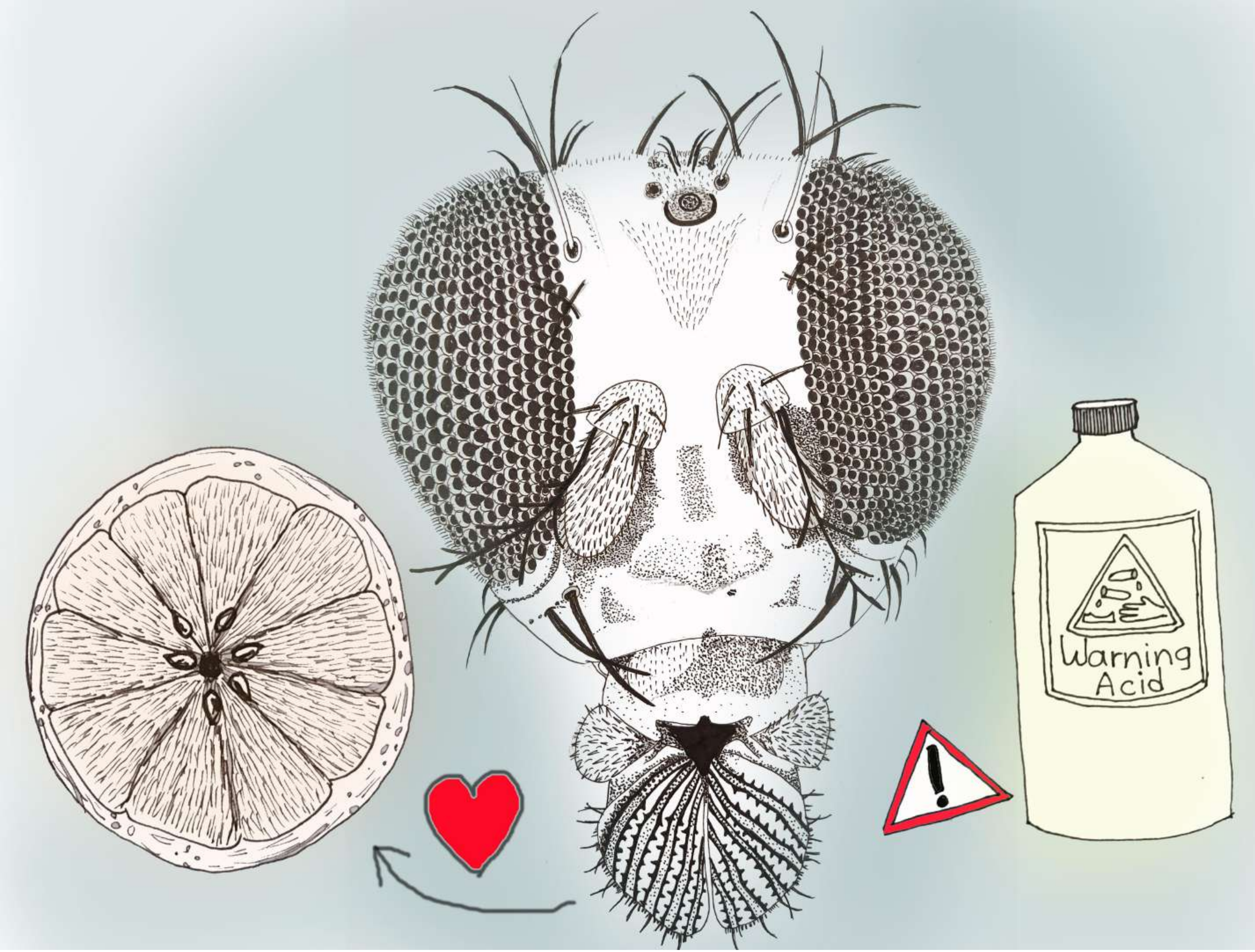
Shown here are the neurons that express clock genes, drawn based on a book chapter by Charlotte Helfrich-Förster



Drosophila learning and memory

In nature, *Drosophila* uses repertoire of behaviour to navigate in seearch of food, mates and away from predators. This suggests that flies can use memories to inform decisions.

Scientists have developed assays to examine memories that restrict behavioral choice to understand genetics and neural systems of memory formation in the fly. Olfactory, visual, and place memory paradigms have proven influential in determining principles for the mechanisms of memory formation.



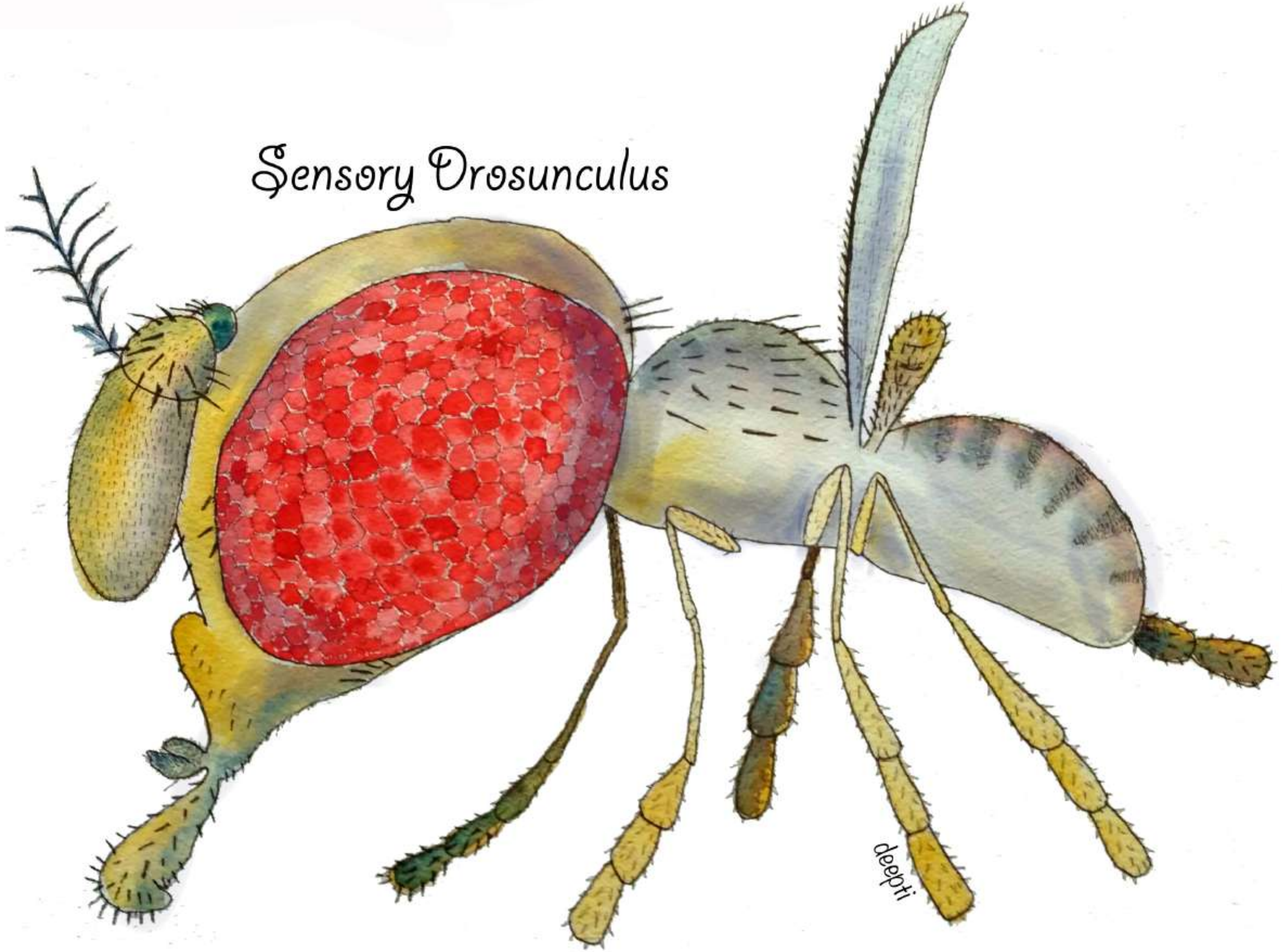
Chemosensation- Taste

Drosophila tastes through taste receptors located in their proboscis, legs and body.

They have receptors for sweet, salty, bitter and umami.

Recently, Yali Zhang lab at Monell Chemical Senses Center discovered Otopetrin-like a as a bonafide sour taste receptor in flies.

Loss of OtopLa causes loss of attraction to low-acid food while keeping the aversion of high-acid food intact suggests 2 separate pathways.

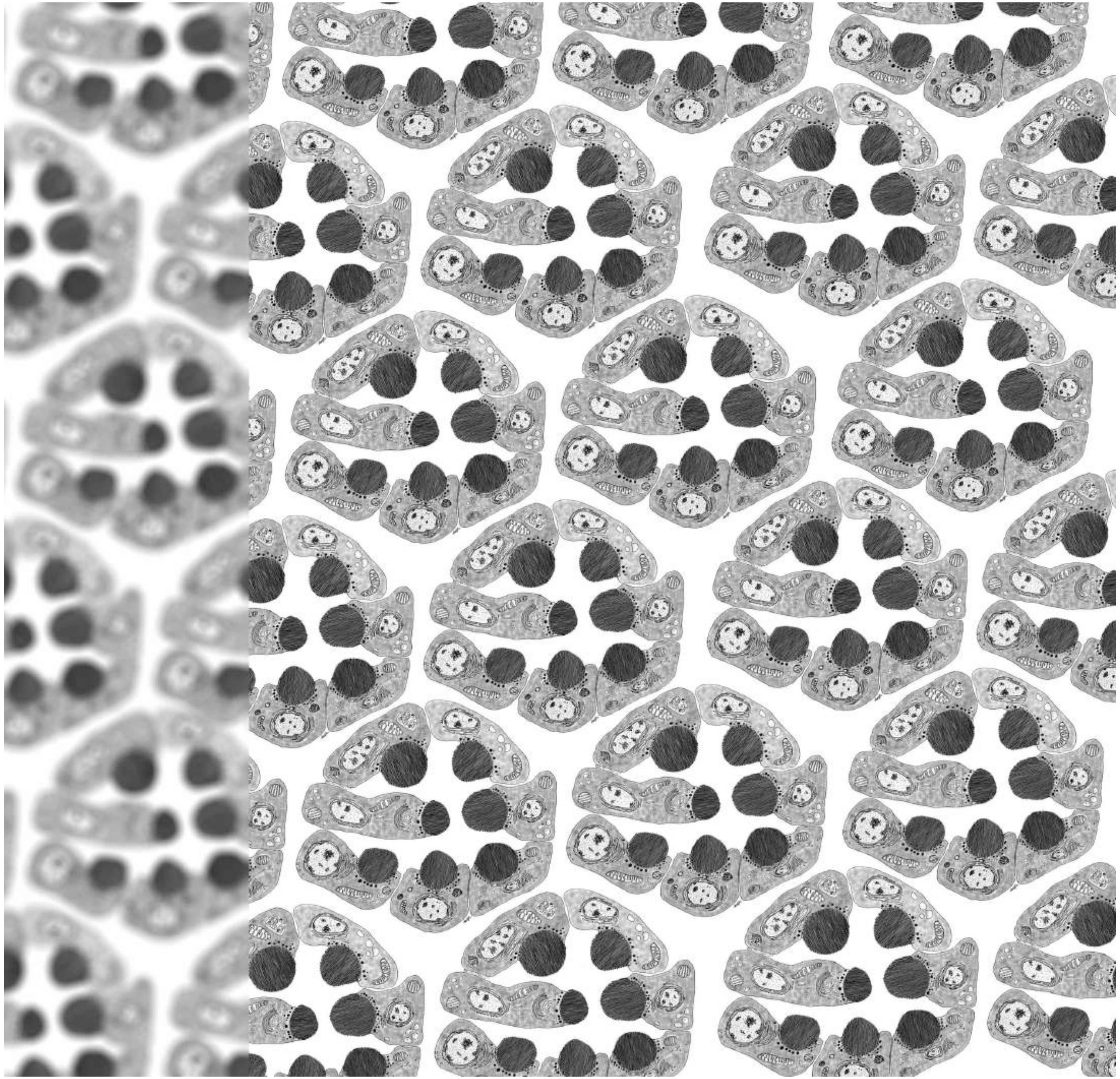


Sensory Drosunculus:

Named after **Sensory homunculus**, this image depicts a representation of Drosophila sensory neurons onto the body.

Body parts have been drawn in proportion to the number of sensory neurons it has.

For example, antennae have 1200 sensory neurons while eyes have 6400 sensory neurons approximately. Upper wing margin have sensory neurons while the rest of the wing blade does not.



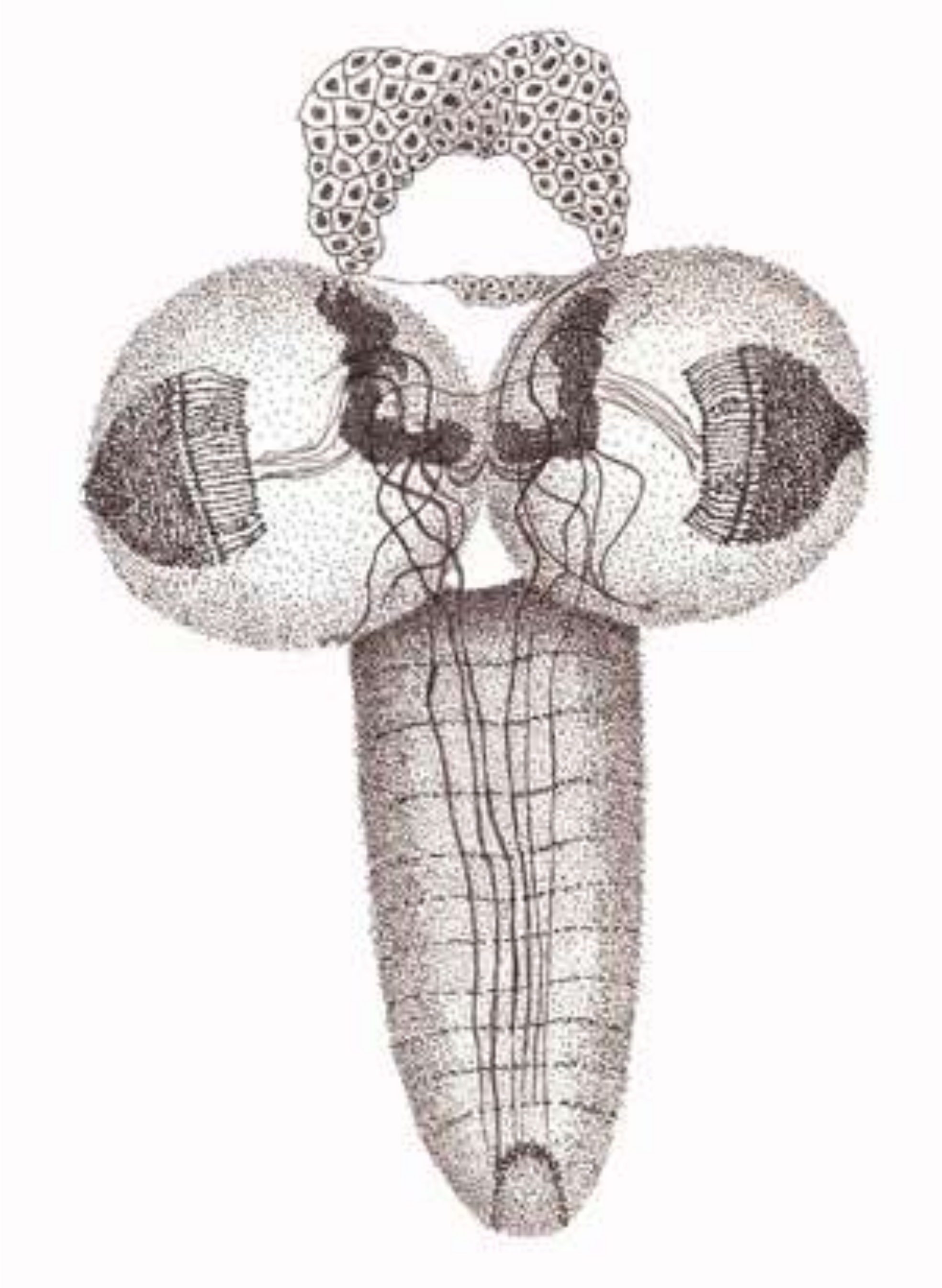
How acute is fly vision?

One might wonder that flies should see fuzzy considering their compound eyes have relatively few ommatidia.

In fact, although fly visual behavior is saccadical, their visual sampling exceeds the compound eyes' optical limits.

Refractory phototransduction and rapid photomechanical photoreceptor contractions jointly sharpen retinal images of moving objects in space-time, enabling hyperacute vision.

To read more https://elifesciences.org/articles/26117



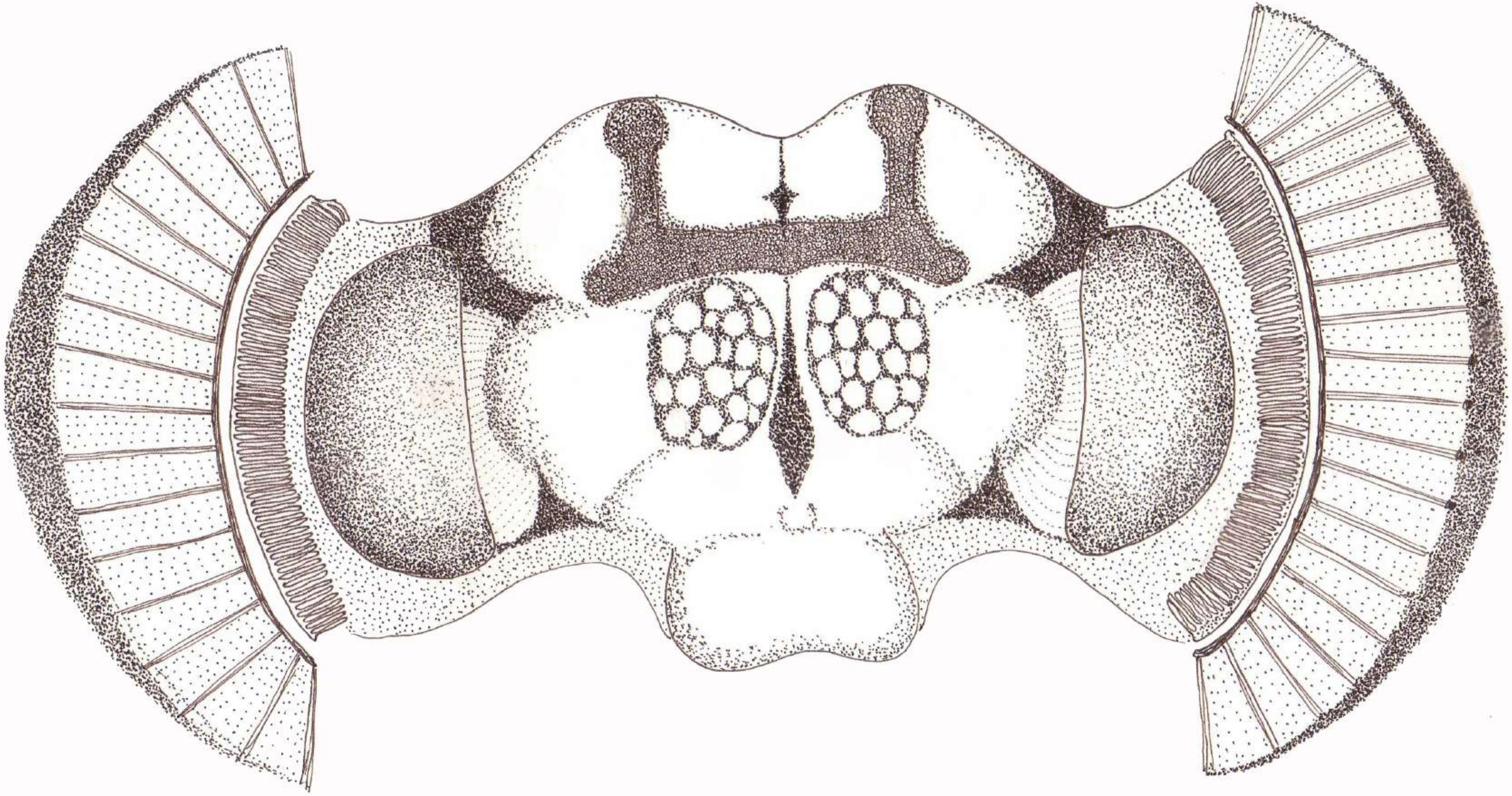
Studying *Drosophila* brain

Drosophila brain anatomy is being studied in great details thanks to genetics and optogenetics tools.

A large number of Gal4 drivers have helped to localise and manipulate specific neurons involved in specific behaviour and functions. This has led to building of precise *Drosophila* brain map.

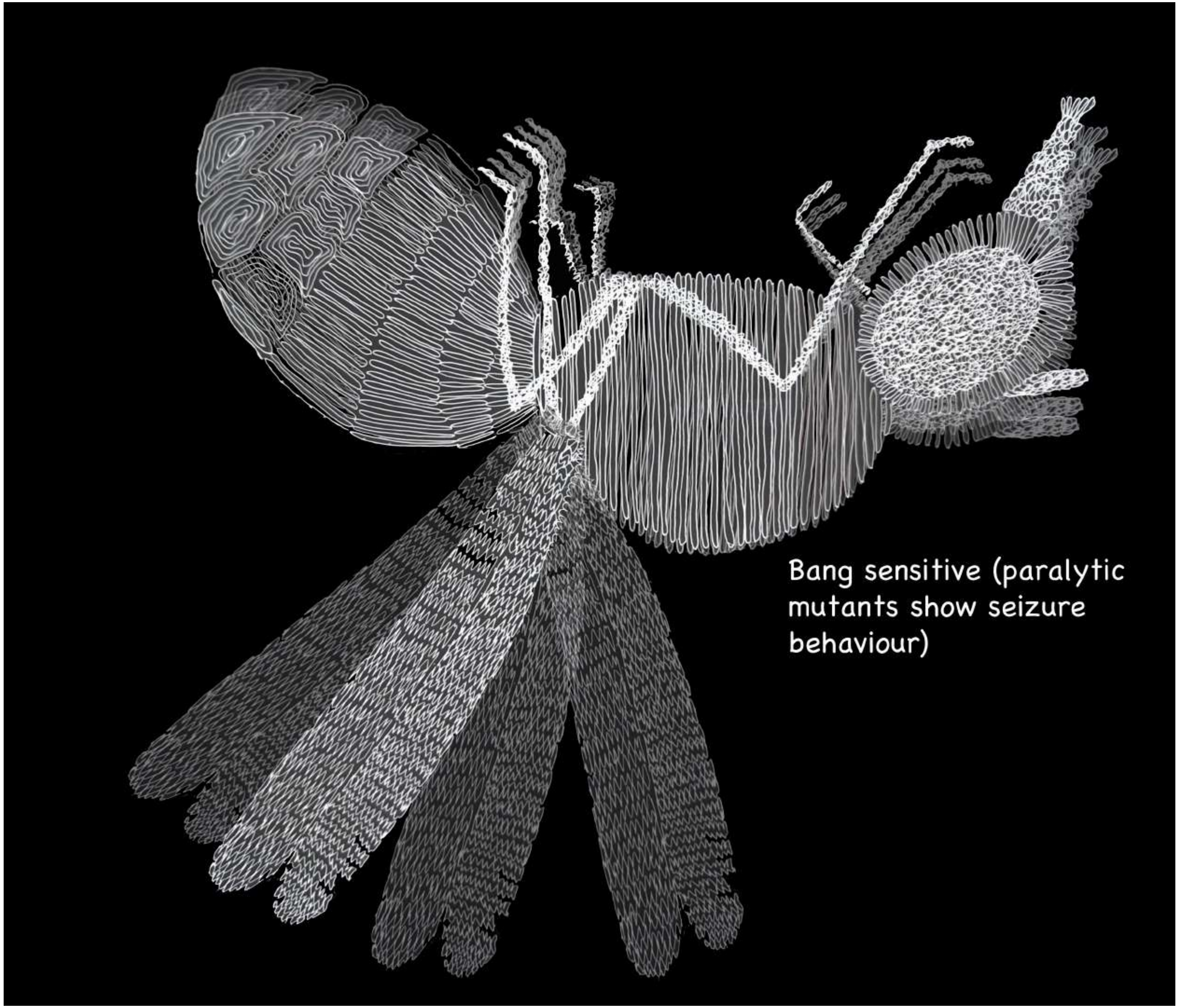
We continue to understand *Drosophila* brain at cellular, chemical and connectome levels and find many connections between brains of higher organisms.

Here I depict a larval brain



Adult brain

Most *Drosophila* larval neurons persist through adulthood and survive metamorphosis as seen by persisting Gal4 expression patterns from larvae to adults. Does acquired memory in larvae also persist through adulthood?



Bang sensitive and paralytic mutants

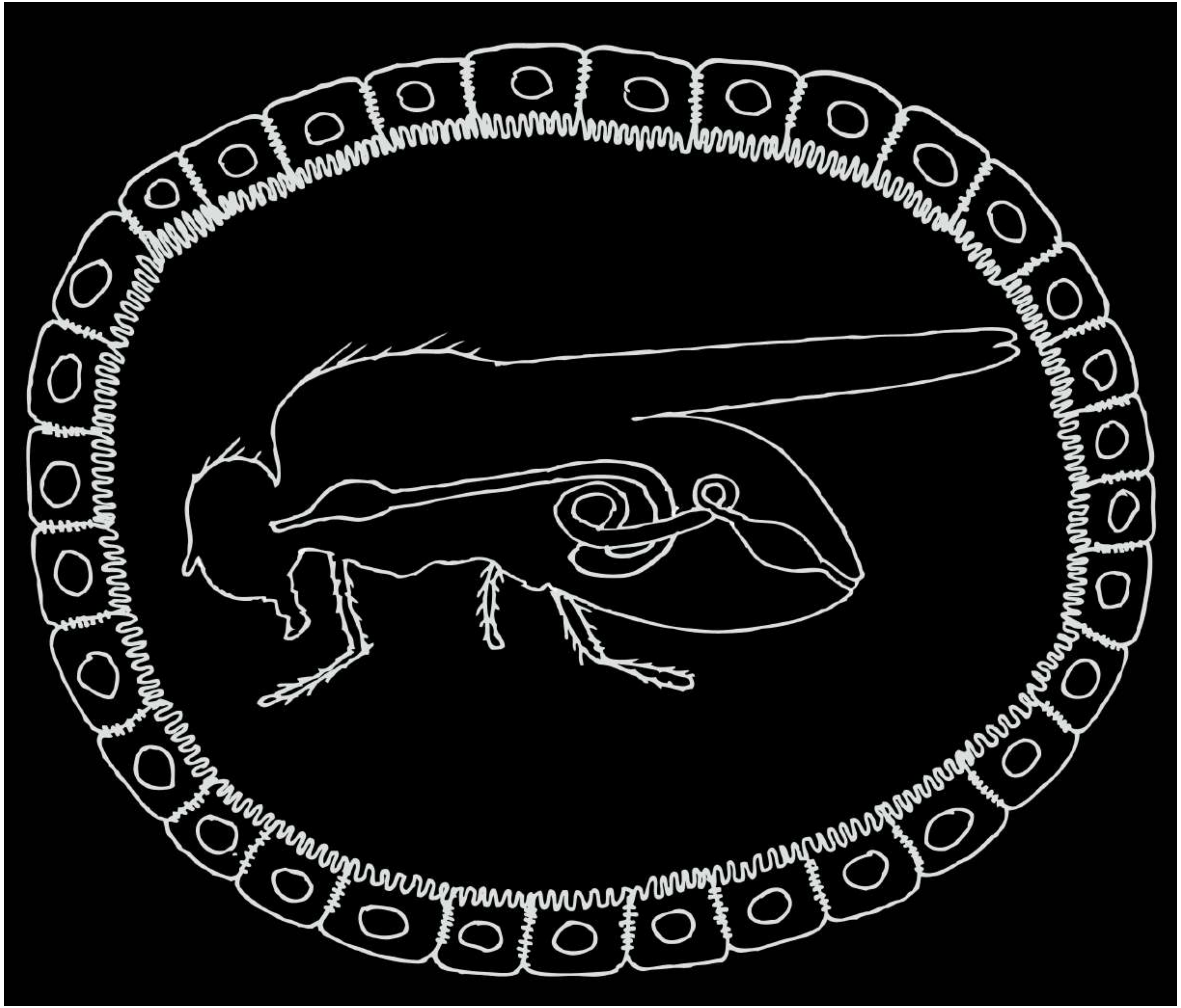
Neurons in the brain spark and convey information to each other.

What happens when it goes awry?

Paralytic gene encodes a subunit of Voltage gated Sodium channel required for action potential. Mutations in this gene lead to paralysis, bang sensitivity, seizures.

Mutants in this gene have been used as a tool to activate and inactivate neurons of different types to understand their roles in Drosophila.

They have also sparked curiosity among school kids as they can be used to induce the seizure behavior or paralysis.

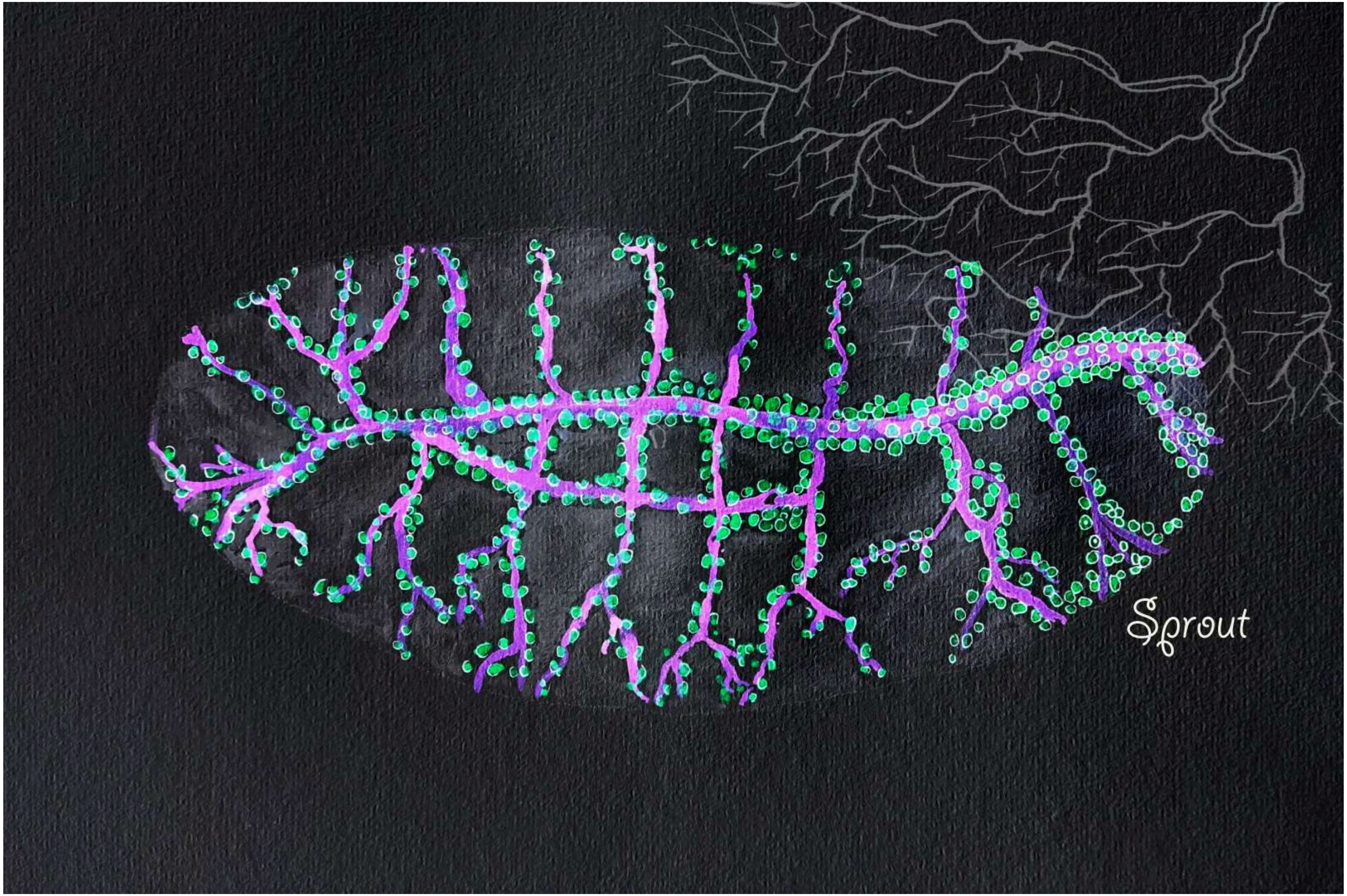


Drosophila gut

Chill susceptible insects die at low temperature due to cold induced loss of ion and water homeostasis. This kind of osmolyte leak leads to hemolymph hyperkalemia, cell depolarization and cell death.

At low temperatures flies have increased rates of paracellular leaks through gut epithelia, which is reduced significantly in cold acclimated flies. This way cold acclimated flies can maintain homeostasis and avoid injury better than warm-acclimated flies.

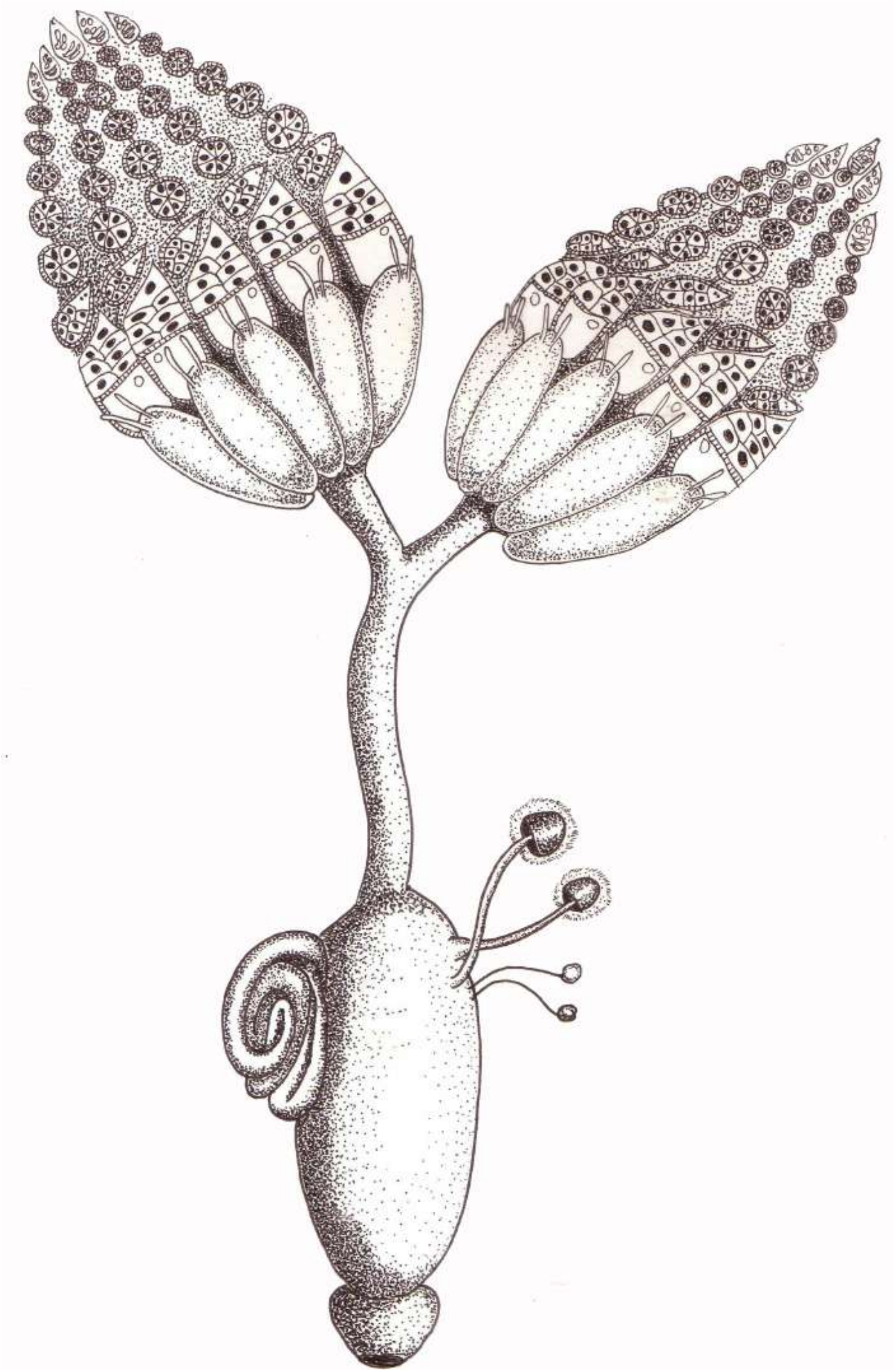
Improved barrier function is associated with changes in the abundance of septate junction proteins & changes in ultrastructure of subapical intercellular regions of contact between adjacent midgut epithelial cells.



Trachea

Drosophila tracheal terminal branches are plastic and have the capacity to sprout out projections toward oxygen-starved areas, in a process analogous to mammalian angiogenesis.

Here I show the tracheal arborization in an embryo.



Germ cells

The *Drosophila* ovary provides an attractive model for studying the extrinsic or intrinsic factors that regulate the fate of germline stem cells.

Drosophila ovary has also been used to study oogenesis. Oogenesis is a complex developmental process that involves spatiotemporally regulated coordination between the germline and supporting, somatic cell populations.

In addition, countless studies of oogenesis have provided mechanistic insight into broader biological topics such as stem cell niche regulation, cell differentiation, cell cycle and size control, epithelial morphogenesis, cell migration, tissue repair and homeostasis.