Bachelor project 1:

Title: **Screening of Transcription factors for their role in photoreceptor development and specification in *Drosophila melanogaster***

Group: Prof. Simon Sprecher

Supervisor: Abhishek Kumar Mishra

Project description:

Specific light-sensitive photoreceptor neurons in the eye transform information such light intensity or color information into electrical neuronal signals. The developmental process coordinating the expression of specific sensory receptor genes thus provides functional identity of a sensory neuron.

Drosophila melanogaster has long served as a model to study the development and specification of photoreceptors. Photoreceptors are the cells that perceive light with the help of their receptor molecules, called rhodopsins. Development of all the photoreceptors starts during embryogenesis and it has been shown that it requires a group of transcription factors and cell signalling molecules at different embryonic stages. By the end of embryogenesis, these photoreceptors are specified into *rhodopsins*. We have performed microarray analysis and a yeast one hybrid screen to identify candidate transcription factors required for the development and specification of photoreceptors. Comparing the candidate genes we have established a list of high confidence transcription factor candidates. These genes include: *chinmo*, *sequoia*, *vrille*, *Ptx1* and *ems*. Our aim is to identfy the function of these transcripton facturs in photoreceptor development and *rhodopsin* regulation.

The current project involves three parts:

1) Analysis of their expression pattern in the embryo and in the larvae using antibody and gene specific Gal4 lines. Technically, this work involves immunohistochemistry and imaging using a high-resolution confocal microscope.

2) Study of the effect of knock-out and knock-down of these genes in photoreceptor development and *rhodopsin* expression using mutants and RNAi lines that we have identified.

3) Study of the effect of overexpression of these genes in regulating photoreceptor development and specification.

This project will help us understanding the genetic pathways that allow the visuals system to develop.

Bachelor project 2:

Title: **Dissection of the light processing circuit of *Drosophila* larva.**

Group: Prof. Simon Sprecher

Supervisor: Dr. Abud Farca

Project description:

Light is one of the most important environmental signals for living organisms. Photoreceptors (usually located in the eyes) transform photic signals into chemical signals that reach higher order brain centers. Here information is integrated and processed in a neuronal circuit. The output goes to effector organs to modify behavior. We are studying the visual system of the fruit fly larva *Drosophila melanogaster* to address basic questions on how light information is processed to impact behavior.

In the *Drosophila* larva, the Bowlig´s Organ (or larval eye) contains the photoreceptor neurons. The photoreceptors connect to second order neurons located in the central brain where light information is integrated and sent to effector organs. Recent publications from our lab predict twelve neurons that integrate photic information. This model has the advantage of being simple. The connectivity and network organization of this neurons remains far from being elucidated and will be the aim of this project. A plus is that multiple genetic tools for *Drosophila* are available, that makes the model even more exiting.

In collaboration with labs in Stanford we are implementing InSITE, a state of the art tool. To decipher the larval visual circuit and extend anatomical knowledge a recent anatomical screen has already provided new candidates for the visual circuit. Further, to crack the fly's visual circuit, Flybow, a novel technique will be used. This technique is similar to Brainbow, which has been employed to study brain circuits in more complicated systems as mammals. Both techniques are based on expression of multiple genetically encoded fluorescent proteins that allows visualization of neuronal morphology in high detail. Combining Flybow technique with our anatomical screen will allow us to identify single neurons and reconstruct the larval light processing circuit.

In this project you will use innovative techniques and you will develop your skills on *Drosophila* genetics, larval brain dissections, immunostainning, confocal microscopy and image processing.

Bachelor project 3:

Title: The neuronal network underlying visual learning in *Drosophila*

Group: Prof. Simon Sprecher

Supervisor: Alina von Essen

Project description:

The eye of *Drosophila* larvae consists of only a few photoreceptors. The photoreceptors transfer the light information to few well-described target neurons. Despite this neuronal simplicity *Drosophila* larvae are able to perform complex tasks such as the formation of visual memories. Therefore the visual system of the *Drosophila* larva is a great model system to study the mechanisms of learning and memory formation. In this project you would genetically ablate single neurons of the visual system and proof the absence of the neurons using confocal microscopy. In a second step you would perform behavioral experiments and study the role of the ablated neuron for visual learning.

Titel: Das dem visuellen Lernen zugrunde liegende neuronale Netzwerk in *Drosophila*

Projektbeschreibung:

Das Auge der Fruchtfliegenlarve besitzt nur sehr wenige Photorezeptoren. Diese geben die Lichtinformation an nur wenige bereits bekannte Zielneurone weiter. Trotz der reduzierten Anzahl von Neuronen sind Fruchtfliegenlarven in der Lage komplexe Aufgaben zu lösen, wie zum Beispiel die Bildung eines visuellen Gedächtnisses. Deswegen ist das visuelle System der Fruchtfliegenlarve ein gutes Modellsystem um die neuronalen Mechanismen des Lernprozesses und der Gedächtnisbildung zu studieren. In diesem Projekt wirst du einzelne Neurone des visuellen Systems genetisch ablatieren und deren Abwesenheit unter dem Konfokal Mikroskop überprüfen. In einem zweiten Schritt wirst du Verhaltensexperimente durchführen und die Rolle der ablatieren Neurone für die visuelle Gedächtnisbildung studieren.

Bachelor project 4:

Title: **A comparative analysis of the serotonin neurotransmitter among castes in the ant *Cardiocondyla obscurior*.**

Group : Prof. Simon Sprecher

Supervisor : Joris Bressan

The tropical ant of the genus *Cardiocondyla obscurior* is a social insect in which the colony is organised in four specific castes, the female individuals being divided in the two castes of *queens* and *workers* and the male individuals divided in *ergatoid (wingless) male* and *winged male,* each of one them behaving in a distinct way. These characteristics (together with a small colony size, the easy maintenance and a relatively simple nervous system) make this species a promising model organism to study the neuronal basis of complex behaviours.

A preliminary comparative analysis of the brain anatomy has demonstrated that there are major differences in brain structures among castes, giving the anatomical basis for the explanation of the diverse behaviours known.

Neurotransmitters are the base of the information transmission in the nervous system and are responsible for the behaviours. Serotonin (5-hydroxytriptamine) has been demonstrated to orchestrate behaviours like aggression and feeding in insects.

The aim of this project is to analyse the anatomical localisation in the nervous system of the serotonin neurotransmitter for each caste and to compare these results among castes. This work will give us a better understanding of how the known behaviours shown by the castes individuals can be qualitatively different.

To investigate this topic you will use and learn different techniques as the dissection of an insect, the immunostaining to label structures and molecules, the confocal microscopy and the computer image processing.