PhD position in the evolution of neural circuits or evolution of toxin resistance
Benton Laboratory

PhD projects are available in two areas:

First, how do new neuronal circuits evolve? We approach this fascinating question in the olfactory system of *Drosophila*. Olfactory pathways are one of the most dynamically evolving parts of the nervous system: animals frequently acquire (and discard) olfactory receptors, circuits and odour-evoked behaviours with the ever-changing landscape of stimuli in their environment. The evolutionary flexibility of olfactory systems is reflected in their modular organisation: in insects (as in vertebrates), most individual olfactory sensory neurons (OSNs) express just one olfactory receptor gene, and the axons of OSNs expressing the same receptor converge on discrete regions of neuropil (glomeruli) within the primary olfactory centre, where they synapse with second-order neurons. The numbers of olfactory receptors vary widely across species, with concordant diversity in the number and organisation of OSNs and glomeruli in the brain. Using developmental genetics, single-cell sequencing and circuit tracing methods in the peripheral olfactory system of *Drosophila melanogaster* and closely-related drosophilid cousins, our lab is studying: (i) the mechanisms and evolution of olfactory receptors' singular expression properties, (ii) how novel populations of OSNs arise through changes in patterns of neurogenesis and developmental programmed cell death, and (iii) how OSN populations are segregated to distinct glomeruli to form unique sensory channels in the brain, and how these guidance mechanisms are modified to create new glomeruli. The mechanisms and molecules we characterise are likely to be relevant for understanding circuit formation and evolution in other brain regions and species.

Second, while environmental chemicals are often exploited as beneficial signals, for example, to locate food or conspecifics, many chemicals are toxic, including inorganic compounds and those produced by plants to deter herbivores. How do such chemicals enter animal bodies and transfer between tissues? Do they have unique, multiple, or general molecular and cellular targets? What are the defense mechanisms of animals against intoxication? These questions span the fields of chemical ecology, sensory neuroscience, physiology, metabolism and evolutionary biology, and are of general relevance for animal and human health. The susceptibility and resistance of insects to toxic chemicals is of particular interest because these mechanisms reflect one side of an evolutionary arms race of species with plant food sources or venomous predators. Moreover, for millennia, humans have used chemicals – sometimes derived from or inspired by plants – to combat insects that damage our agriculture or act as vectors of pathogens. Countless insecticides exist, encompassing both natural and artificial chemicals. While the mode-of-action of a subset of these is very well-understood, for many insecticides the precise mechanisms by which they cause toxicity are unclear. Moreover, the molecular and tissue bases by which insects have evolved the ability to tolerate and/or resist artificial or natural insecticides are only partially understood. We are developing a new research programme using experimental evolution, genome wide association studies, comparative genomic, genetic, cellular and whole-animal functional assays in *D. melanogaster* and other insects to understand the mechanisms of susceptibility and resistance to insecticides.

The specific PhD project will be developed together with the successful candidate in one of these areas, depending upon their interests and expertise.