Figure 1 Mushroom bodies from the fruitfly *Drosophila melanogaster*. These paired structures are thought to be an information-processing centre, and Liu *et al.*³ now show that they are involved in context generalization during learning.

to be a high-order information-processing centre^{4,5}. In *Drosophila* they are related to olfactory processing and formation of olfactory memories¹, but they do not seem to be involved in visual processing and memory⁵.

The authors used three different techniques to remove the mushroom bodies (an *mbm* mutant lacking mushroom bodies; selective pharmacological ablation using the cell poison hydroxyurea during the first larval stage; and reverse-genetic ablation by enhancer-driven tetanus toxin), and showed that visual input affects the mushroom bodies. They suggest that the mushroom bodies do a dynamic analysis of the structure of the environmental stimuli, such that their temporal trace is compared to that of the unconditioned stimulus. (A similar function has been proposed for the honey-bee mushroom body, based on rather different data⁶.) Only the visual stimuli that change in a synchronous way with the heat stimulus can be useful predictors of dangerous heat. Other stimuli have a temporary structure, different from that of the unconditioned stimulus, so they are classified as 'context'. Flies that lack mushroom bodies cannot generalize their learned response to a different context because they are unable to dissociate the visual patterns from the illumination under which they were trained. In these flies, a compound between context and conditioned stimulus is formed. So, when the context changes, the compound changes too, impeding generalization to a new context.

The mushroom body seems to have three general functions. First, it separates stimuli according to their temporal structure. Second, it evaluates these stimuli with respect to the unconditioned stimulus (context or predictor). Finally, during the retention phase, it grades the stimuli according to predictive power. Such a proposal for a structure–function relationship is similar to a hypothesis by Solomon and Moore⁶ for the hippocampus in mammals — poorly associated conditioned stimuli are 'tuned out', and a hierarchy of stimulus predictiveness is reached. In this sense, the mushroom body may allow

selective attention, an attribute not yet experimentally accessible in insects.

Liu and colleagues' study also provides a fresh view of context dependence, an old issue in learning psychology. The textbooks tell us that animals can learn different meanings for the same stimulus when it is presented in different contexts. They maintain that contextual and conditioned cues appear to an animal as separate sensory entities, which may be associated in different ways⁷. *Drosophila*, on the other hand, seem to use a different system in which contextual cues and conditioned stimuli are filtered by the mushroom bodies. If this idea is correct, *Drosophila* may never have the flexibility to establish different, conditional relationships between contextual and conditioned stimuli.

But does the *Drosophila* mushroom body indeed act only on a basic sensory-processing level, as suggested by Liu *et al.*? Flies that lack the mushroom body perform tasks according to strict training conditions, indicating that sensory processing and association are done and stored outside the mushroom body, probably in the visual ganglia. So, the mushroom bodies might be related to the organization of multiple memories. It is possible that storage or retrieval initiates a search routine for additional conditional forms of memory traces — such as a trace indicating one stimulus as the contextual cue and the other as the conditioned stimulus. Such a trace would reside in the mushroom bodies, and would carry the information about whether the context or the conditioned stimuli were stable or variable. Flies deficient in the mushroom bodies may lack this trace, so would behave exactly as Liu *et al.* describe.

Although Liu and colleagues' data do not require such an elaborate model, their experiments have not yet tested it. The next steps may be to try and uncouple the function of mushroom bodies during acquisition, storage and retrieval, and to test combinations of contextual and conditioned cues in a balanced fashion. *Drosophila* will be an ideal organism in which to do these experiments, given the tools available for inducible knock-out mutants. In any case, the mini brain of this little fly is now well qualified as a model for basic cognitive functions. □

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Daedalus

Superficial complexity

Metallic mercury has a high surface tension. But make it an electrode in an ionic solution, apply a voltage, and ions crowd its surface in surfactant fashion. Its surface tension drops dramatically. Non-ionic additives can reduce the tension even further. Daedalus is now taking this electro-capillary effect to extremes, using other metals.

He has set up a heated electrochemical cell with a molten metal electrode at the bottom, and a layer of molten salt above it as electrolyte. The vastly greater ion density of the melt will reduce the surface tension of the metal interface far more. Indeed, with a high enough voltage, a well-chosen salt, and some cunningly selected non-ionic additives, the surface tension of the metal could be driven negative.

A liquid with negative surface tension should increase its surface area vigorously. In the simplest case it might break into separate droplets; but not in Daedalus's system. Once detached from the bulk, a globule would cease to share its voltage. It would revert to positive surface tension, and reattach itself. Instead, the metal surface will fold into some nightmarishly complex fractal, dense with tiny corrugated corrugations of vast total surface area, but still all one surface.

Powerful applications beckon for this new metal treatment. Catalysis, heat exchange, electrode forming, battery and capacitor manufacture, all cry out for metals of the highest possible surface area. Daedalus is planning a 'continuous fractalization bath', in which a strip of base material, coated with the metal to be fractalized, runs at high speed through his molten-salt cell. The coating melts, acquires negative surface tension, blooms into vast surface area, and sets solid again in a cooler region of the bath downstream. Its adhering salt coating is washed off with water, and it is reeled up.

The pilot studies will use platinum, whose catalytic surface is crucial to so much chemistry. A possible salt for the job is potassium hydrogen sulphate; its melt cleans platinum so splendidly that it may be a natural surfactant for the metal. But Daedalus's fractal metal surfaces should find many other uses. In particular, they will be ideal for gluing and bonding. Unlike surfaces made by grinding or scoring, they will have re-entrant cavities and protrusions on all scales, and will keep an applied paint or resin immovably in place. Even PTFE-coated saucepans will at last retain their slippery coating.

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