β-amyloid, the peptide that forms the main component of plaques found in the brains of patients with Alzheimer's disease.

More broadly, the fundamental questions about the molecular origins of the context dependence of hydrophobicity raised by Ma and colleagues' work are ripe for investigation using theory simulations and experiments. Addressing these questions is important, because the findings reassert that the different factors involved when two proteins (or two chemically heterogeneous surfaces) interact with each other are not additive — throwing a spanner in the works of simplistic models that assume this. ■

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NEUROSCIENCE

Dragonflies predict and plan their hunts

An analysis reveals that the dragonfly's impressive ability to catch its prey arises from internal calculations about its own movements and those of its target — the first example of such predictions in invertebrates. SEE ARTICLE P.333

STACEY A. COMBES

Imagine a ballet dancer moving across the stage to meet his partner, who is leaping and pirouetting towards him. To catch her at the right moment, he must predict where she will end up and determine how he should move to intercept her. To do this, his mind anticipates how her image should grow as they move towards each other, allowing him to rapidly identify and react to unexpected changes, such as a stumble that lowers her speed. Until now, this type of complex control, which incorporates both prediction and reaction, had been demonstrated only in vertebrates. However, in this issue, Mischiati *et al.*[1] (page 333) show that dragonflies on the hunt perform internal calculations every bit as complex as those of a ballet dancer.

Dragonflies are formidable predators. With huge eyes that provide an almost spherical view of the world, they perch on vegetation, waiting for prey to drift overhead. When the time is right, they shoot off in pursuit, scooping up victims with their hairy legs in less than half a second (Fig. 1). Dragonflies succeed in catching their prey about 95% of the time[2,3], and this prowess has been attributed to their visual acuity and lightning-quick reflexes — in particular to the specialized visual neurons that detect the motion of a target and instruct the wings to react[4].

If dragonflies' pursuits were guided purely by their reactions to the movements of their prey, one would predict a one-to-one mapping between prey manoeuvres and dragonfly reactions. Mischiati and colleagues show that this is clearly not the case. Dragonflies do respond to some prey manoeuvres, but more often they do not. And what's more, the authors report that the majority of dragonfly manoeuvres are not associated with any change in prey motion.

Some of these prey-independent manoeuvres are related to the mechanical requirements of prey capture: dragonflies align themselves with the flight path of their prey, approaching from below, most probably to reduce the likelihood of detection. Their bodies and heads move independently during prey capture, with the head remaining locked onto its target[2] while the body manoeuvres into the optimal orientation for capture. Until now, it had been assumed that these target-locking head motions were performed reactively, with dragonflies moving their heads to re-centre the prey after any motion — either their own or that of their prey — that shifts the target from their sights.

To tease apart the causes and consequences of head movements during prey capture, Mischiati *et al.* performed extremely accurate, high-speed measurements of prey position, and of dragonfly head and body orientation. Such measurements are possible only in a controlled, indoor setting, where dragonflies typically refuse to chase prey. To get around this problem, the authors constructed an indoor flight arena, complete with backdrops of natural scenery and lighting that simulated a bright, sunlit day. Once they had quantified the movements of dragonfly and prey, the researchers calculated how the image of the prey moved across the dragonfly's eyes, as the result of the movements of both parties. These calculations revealed that the dragonfly's

Figure 1 | A dragonfly in flight. Mischiati *et al.*[1] found that dragonflies on the hunt make internal calculations about the movements of their prey and themselves.

PHIL DEGGINGE/ALAMY

head motions are remarkably effective at cancelling out the large image drift across the eye that would have resulted from its own body rotations and the prey's anticipated motion. Such cancellation ensures that the prey image remains within a few degrees of the dragonfly's visual acute zone, in which its sight is at its sharpest.

Most notably, these data show that, rather than adjusting head position after the prey image drifts outside the visual acute zone, dragonflies adjust their head positions in near-perfect synchrony with the motions that would cause image drift. This precise timing led Mischiati and co-workers to surmise that dragonflies must be generating predictions using internal models of how prey- and self-motion will affect the location of the prey image on their eyes, and moving their heads to compensate before image drift occurs.

This type of predictive control confers an advantage when compared to a purely reactive strategy. First, although the dragonfly's response time is quite fast (approximately 50 milliseconds), this still accounts for 10% to 25% of a typical chase, so reacting only after each change in prey- or self-motion would extend the duration of a chase considerably. Second, because the dragonfly's own body rotations cause much more image drift than the motion of a distant prey item, nullifying this large image drift before it occurs means that the dragonfly's visual system is more sensitive to unexpected prey manoeuvres, which it can then respond to reactively.

Of course, there is a limit to how much laboratory studies can tell us about dragonfly predation in the wild. The current experiments used either slow, laboratory-reared fruit flies that rarely take evasive action[3], or artificial prey undergoing a single change in speed. So, although Mischiati and colleagues' results indicate that most manoeuvres relate to the dragonfly's pre-choreographed capture strategies, in the wild, dragonflies must contend with prey that behave more unexpectedly. Many wild insects fly erratically at all times, or detect approaching predators and perform evasive manoeuvres. In these cases, reactive control is likely to dominate the dragonfly's actions. Nonetheless, predictive steering strategies presumably still underlie such more challenging pursuits.

More broadly, Mischiati and colleagues' results open up new avenues for exploring the mechanistic basis of complex behaviours involving both predictive and reactive control. In situations such as those presented in this study[1], the brain can align its internal predictions with an appropriate reaction when reality deviates from expectations. These types of behaviour — particularly the use of 'forward models', in which an animal predicts how its own actions will affect its sensory feedback — had previously been demonstrated only in vertebrates[5–7], in which analysis of neural circuitry is challenging. By contrast, dragonflies have accessible neural circuitry, and their relatively large size allows for measurements of behaviour and neural activity during free flight. Hunting dragonflies thus present a rare opportunity for conducting detailed, mechanistic studies of the neural circuits that underlie complex behaviours. ■

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ORGANIC CHEMISTRY

One catalyst, two reactions

A catalyst has been tuned to make different compounds from the same molecules in carbon–nitrogen bond-forming reactions, depending on the conditions used. The products are potential building blocks for biologically active molecules.

EMMANUELLE SCHULZ

The ability to readily synthesize structurally complex molecules containing nitrogen atoms is crucial for organic chemists because such compounds have widespread applications, for example as drugs. But the nitrogen atoms must be incorporated into molecules at particular locations with respect to other atoms, using methods that are compatible with chemical groups already present in those molecules. The three-dimensional arrangement of atoms must also be mastered to prepare 'enantiopure' compounds (single mirror-image isomers of compounds, called enantiomers), rather than a one-to-one mixture of enantiomers that must then be tediously separated. This is crucial for medicinal chemists, because different enantiomers can have different, sometimes even opposing, biological activities. Writing in *Nature Chemistry*, Shi and Buchwald[1] report a variant of a carbon–nitrogen bond-forming reaction that solves many of the problems associated

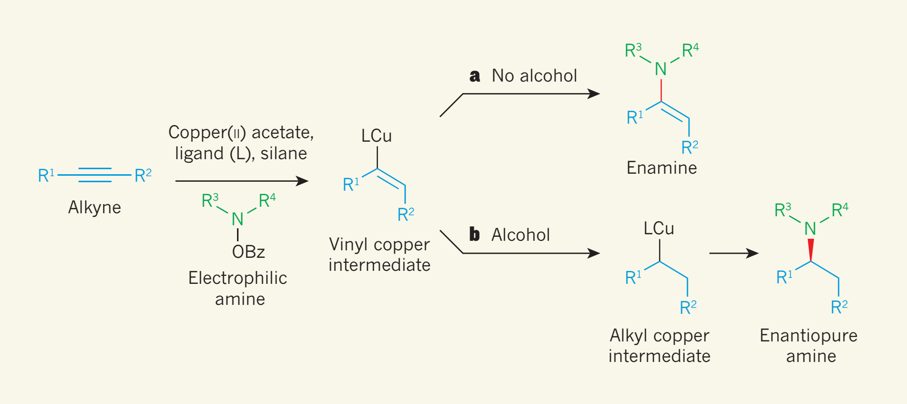

Figure 1 | Selective hydroamination reactions of alkynes. Shi and Buchwald[1] report that a vinyl copper intermediate forms when an alkyne reacts with an electrophilic amine in the presence of copper(II) acetate, a ligand molecule (which binds to the copper ions) and a silane ($HSiCH_3(OC_2H_5)_2$). **a,** In the absence of an alcohol, the intermediate reacts with the electrophilic amine to form an enamine. The carbon–nitrogen bond formed during the reaction is shown in red. **b,** But in the presence of an alcohol, an alkyl copper intermediate forms through a cascade of reactions, and produces amine products in enantiopure form (as single mirror-image isomers). R^1 to R^4 represent general chemical groups; Bz is a benzoyl group.