signaling pathways, not only during differentiation of the nervous system, but also in adult behavior, at least in those neuronal pathways leading to obesity and diabetes.

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Prey–Predator Communication: For Your Sensors Only

Prey have evolved myriad strategies to escape predation. Ground squirrels tailor their defensive signals to the predator at hand and use infrared warning signals in response to heat-sensitive rattlesnakes.

Rachel A. Page

Predator–prey dynamics are a fascinating world of arms races, one-upmanship, and stunning innovation. Predators evolve sophisticated measures to detect and locate prey; prey in turn outmaneuver them with even more sophisticated defense measures, and so the arms race goes [1]. In a recent study, Rundus *et al.* [2] found that ground squirrels are able to exploit the very sensory modality rattlesnakes use to hunt them: sensitivity to heat.

Rattlesnakes use infrared-sensing pit organs to detect warm-blooded prey. While ground squirrels have evolved defensive proteins that partially neutralize snake venom [3], their young are vulnerable until they too develop the proteins. Thus, adult ground squirrels go to considerable lengths to defend their young from snakes. If a snake is present they will harass it by throwing sand or pebbles, wagging their tails ('tail flagging'), approaching and sometimes even biting the offending snake. These behaviors are often effective and snakes are deterred [4].

What was not known until now is that, in response to snakes that are heat-sensitive, ground squirrels add an infrared component to their tail-flagging display. In an elegant set of experiments, Rundus *et al.* [2] showed that rattlesnakes are more deterred by a ground squirrel that has a heated tail than to one that does not. Thus, ground squirrels have developed the ability to tailor their defensive displays to the sensory sensitivity of their predators. Thermal signaling has never been documented before. It is all the more extraordinary to find that ground squirrels are using this modality because they almost certainly cannot detect infrared themselves.

Using a thermal imaging camera, Rundus *et al.* [2] recorded ground squirrel responses to infrared-sensitive rattlesnakes and to infrared-insensitive gopher snakes. Ground squirrels responded to both types of snake with tail-flagging displays, but they added an infrared component to the display in response to rattlesnakes, whereas their tails remained cool when signaling to gopher snakes (Figure 1). To quantify the rattlesnakes' response to tail flagging, the authors presented captive rattlesnakes with a robotic ground squirrel. This robot, built from a taxidermy mount of an actual ground squirrel, could tail flag both with and without heating its tail. Rattlesnakes showed defensive responses significantly more of the time when the robotic tail was heated, indicating that, indeed, rattlesnakes perceive and are deterred by the infrared component of the display.

How well a communication signal functions depends on its

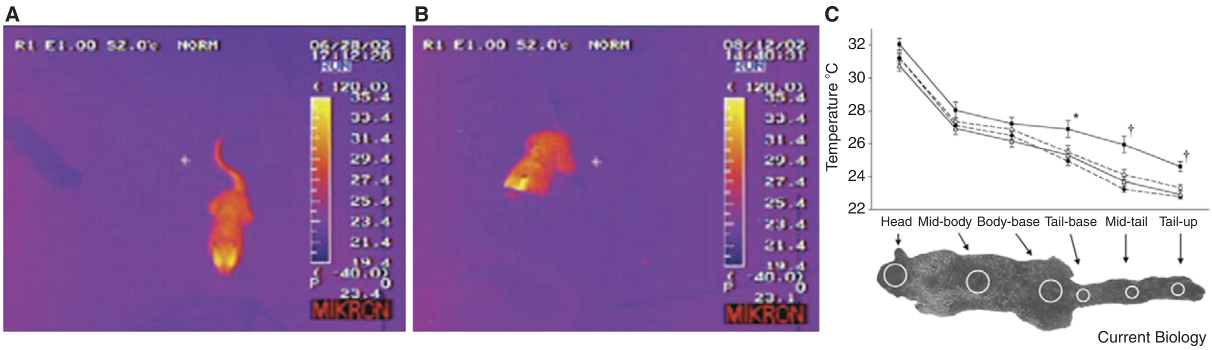

Figure 1. The temperature of ground squirrel tails in response to predator type.

Frames from a thermal imaging camera of a ground squirrel confronted with (A) a rattlesnake, and (B) a gopher snake. Yellows, oranges and reds correspond to warmer temperatures, blues and violets correspond to cooler temperatures. (C) Ground squirrel body temperatures in response to rattlesnakes (squares), gopher snakes (triangles), and two controls: other ground squirrels (diamonds) and baseline (circles). Significant differences in temperatures are found only in the tail region; temperatures are warmest in response to rattlesnakes. (Adapted with permission from [2]; copyright (2007) National Academy of Science, USA.)

production by a sender, how effectively it travels through a medium, and the sensory and cognitive capabilities of the receiver. While studies of animal communication have traditionally emphasized the role of the sender and the medium in signal transmission, until recently less attention has been paid to the role of the receiver [5].

The receiver's sensory capacities serve as filters for the incoming signal. Signals that excite the sensory systems of their intended receivers should be favoured by selection. Numerous examples of signaling within a species show this to be the case. From fish to frogs to fiddler crabs, studies of sexual selection demonstrate that males that produce signals matching females' sensory sensitivity are most successful in obtaining mates (for example, [6–8], reviewed in [9]). Rundus *et al.* [2] have shown that the success of sensory specificity extends to prey–predator communication as well. Prey that communicate to predators in the modality they best perceive can successfully deter attack.

The new study of Rundus *et al.* [2] reminds us that, when studying animal behavior, we must be careful not to confine ourselves to the senses that we ourselves can perceive. In the case of ground squirrels signaling to rattlesnakes, the tail's thermal warning is undetectable to humans and to other ground squirrels alike, but to rattlesnake predators it serves as a potent deterrent. The lesson being, in signal evolution as well as in our study thereof, it pays to be aware of the perceptual world of the receiver.

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Spindle Microtubules: Getting Attached at Both Ends

A recent study describes a novel role for the centrosomal protein Cep57 in attaching spindle microtubules to both kinetochores and centrosomes, suggesting similar mechanisms may be used for generating these two distinct linkages in mitosis.

Jennifer G. DeLuca

In a eukaryotic cell, chromosome segregation occurs on the mitotic spindle, a dynamic array of microtubules which requires the function of numerous proteins at centrosomes, kinetochores and along spindle microtubules (Figure 1A). Chromosomes must attach to spindle microtubules via their kinetochores and maintain persistent linkages to these microtubules throughout mitosis. A