

# 烟青虫触角叶内五羟色胺能神经元



**Xin-Cheng Zhao**

[Helicoverpa@hotmail.com](mailto:Helicoverpa@hotmail.com)

# 昆虫嗅觉:

食物 (寄主气味)

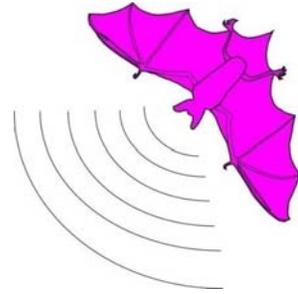
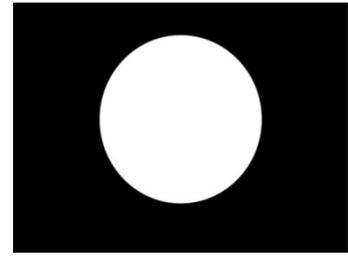
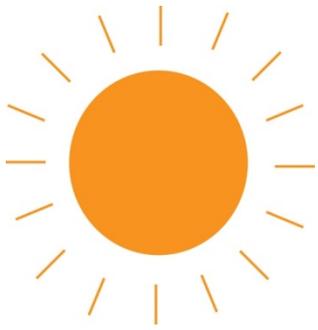
繁殖 (信息素)

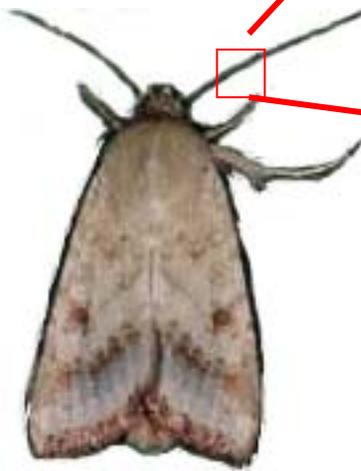
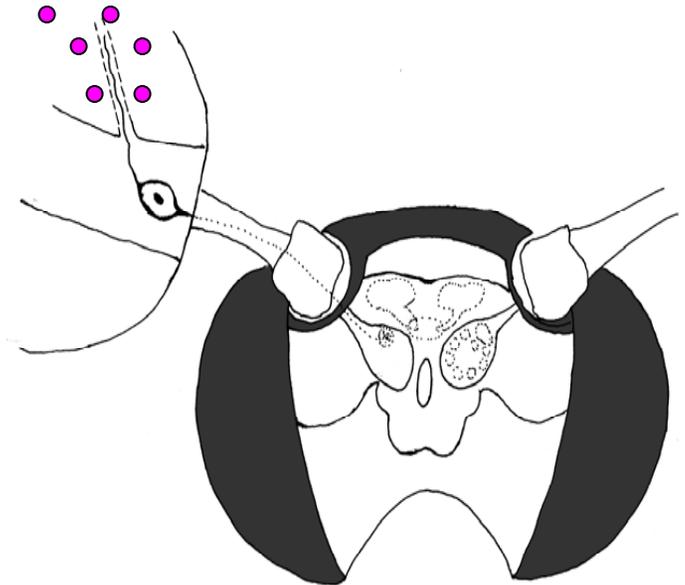
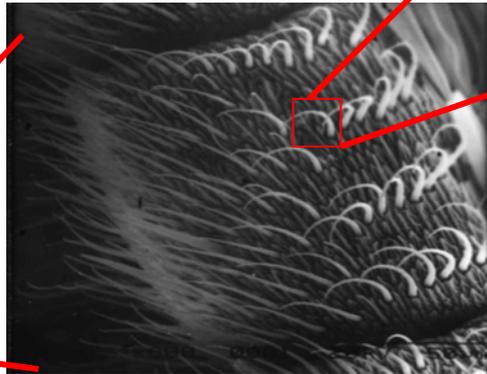
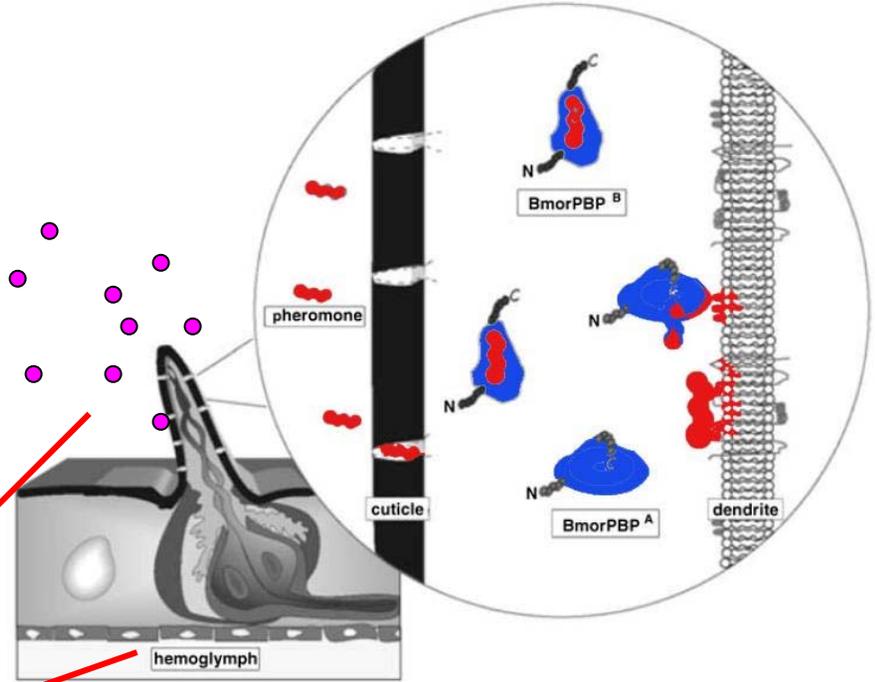
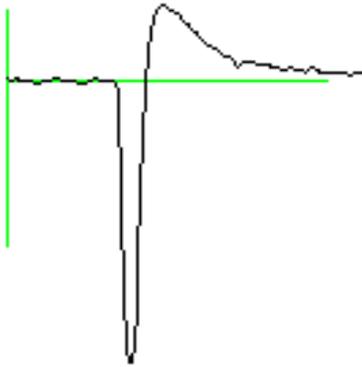


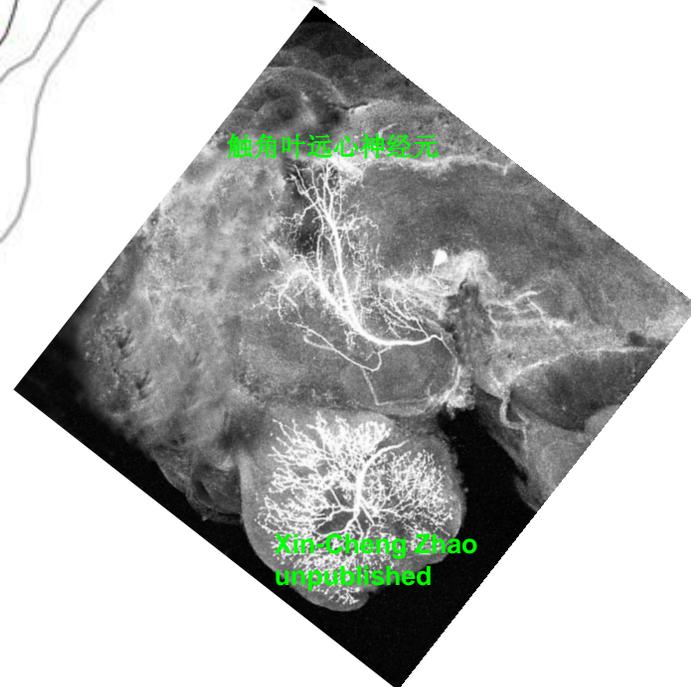
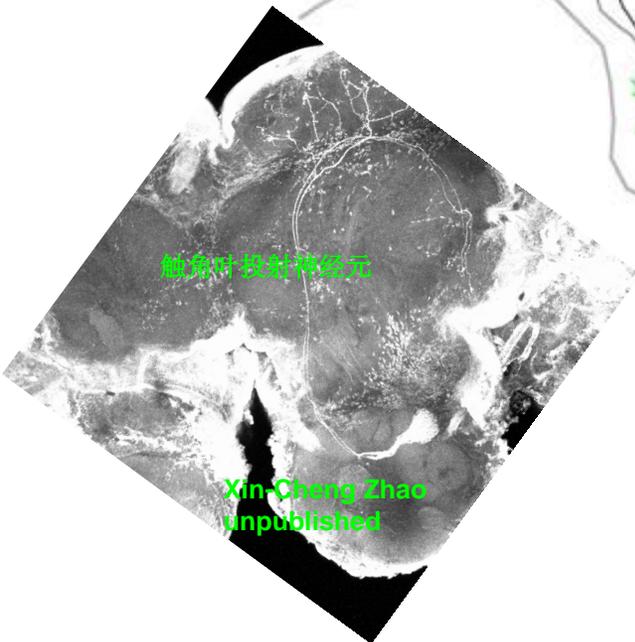
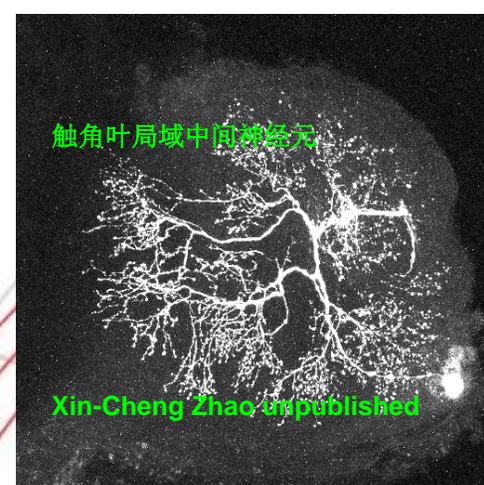
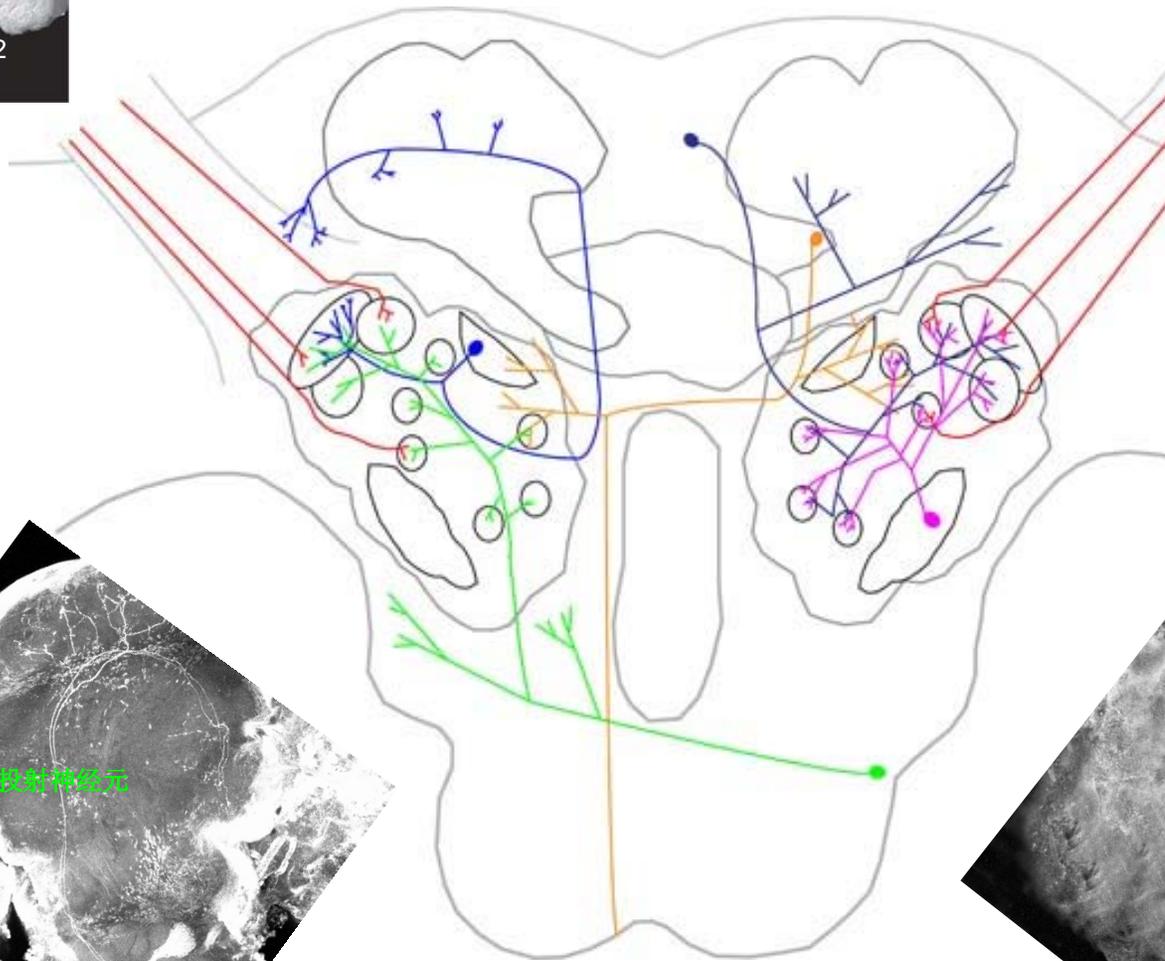
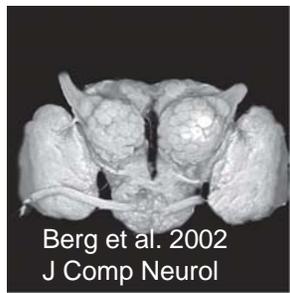
DOI:10.1038/nature05403



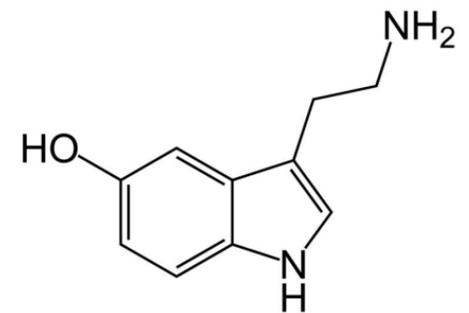
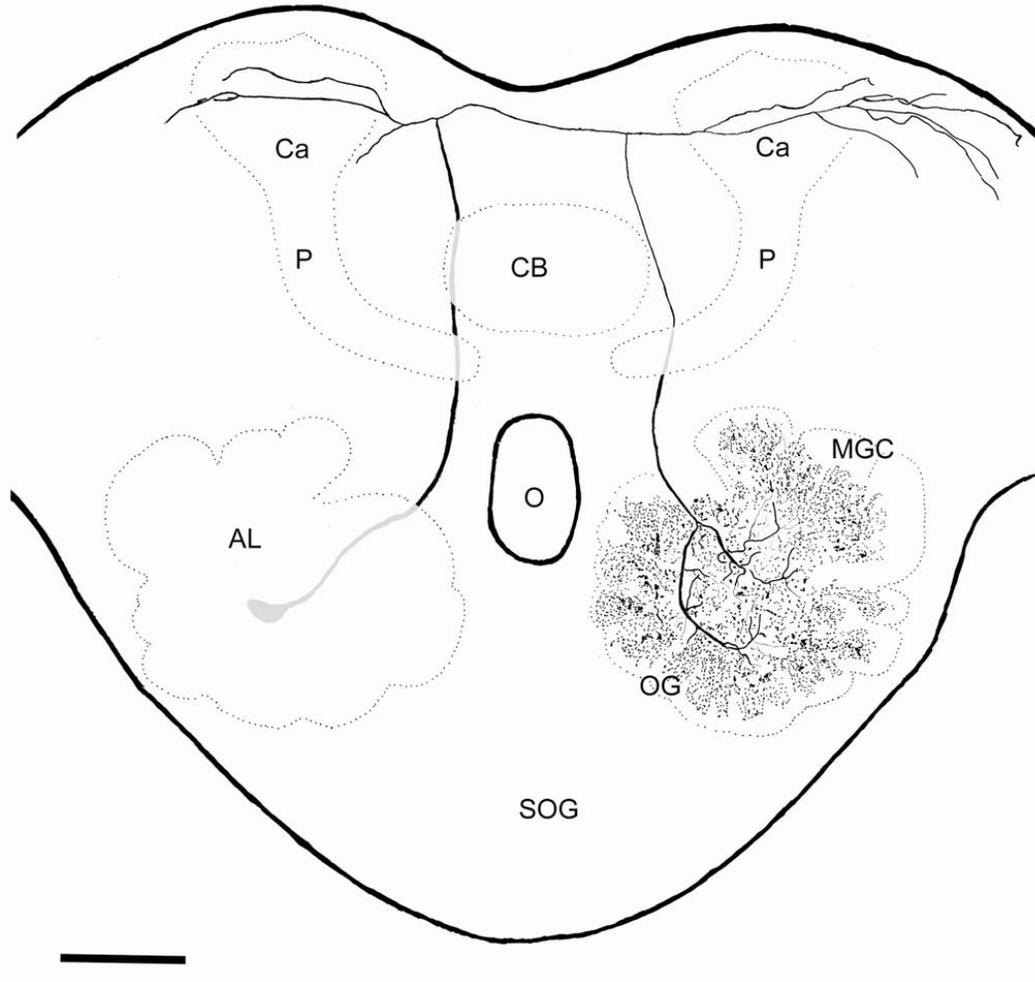
<http://www.biology-blog.com/blogs/archives/Biology-blog/1289319876-Nov-18-2006.html>





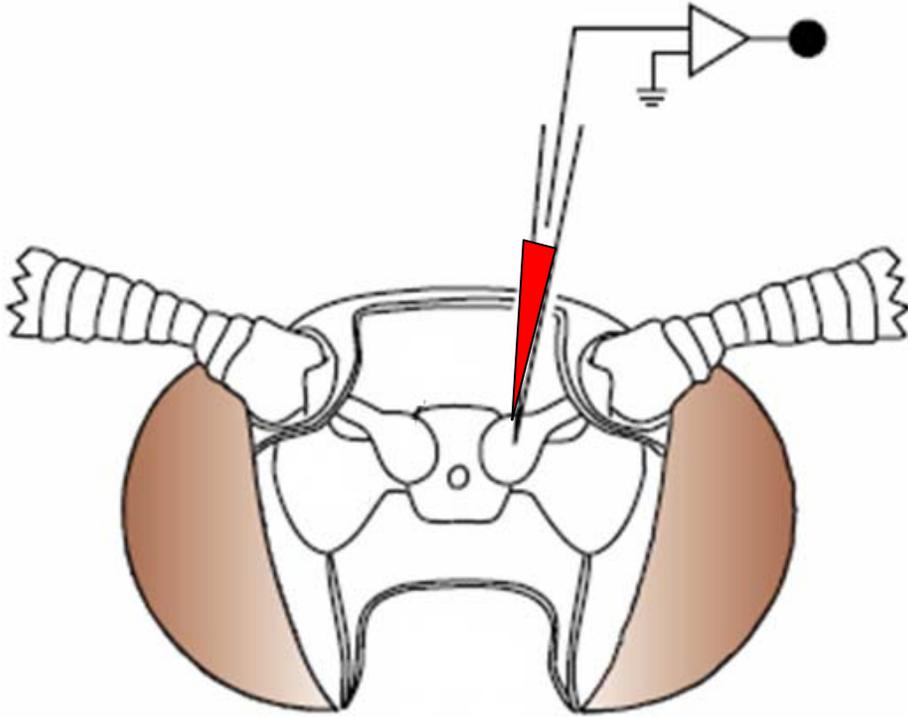


烟青虫脑内五羟色胺能神经元，（抗五羟色胺抗体免疫阳性反应）



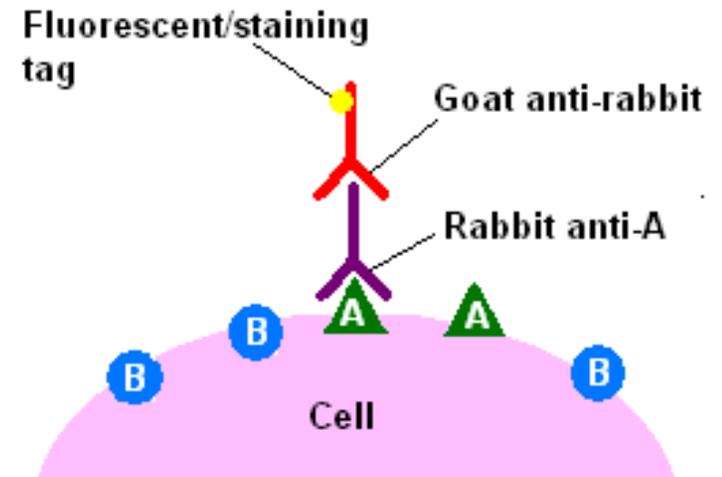
Serotonin, 5-hydroxytryptamine (5HT)

## 细胞内记录和染色



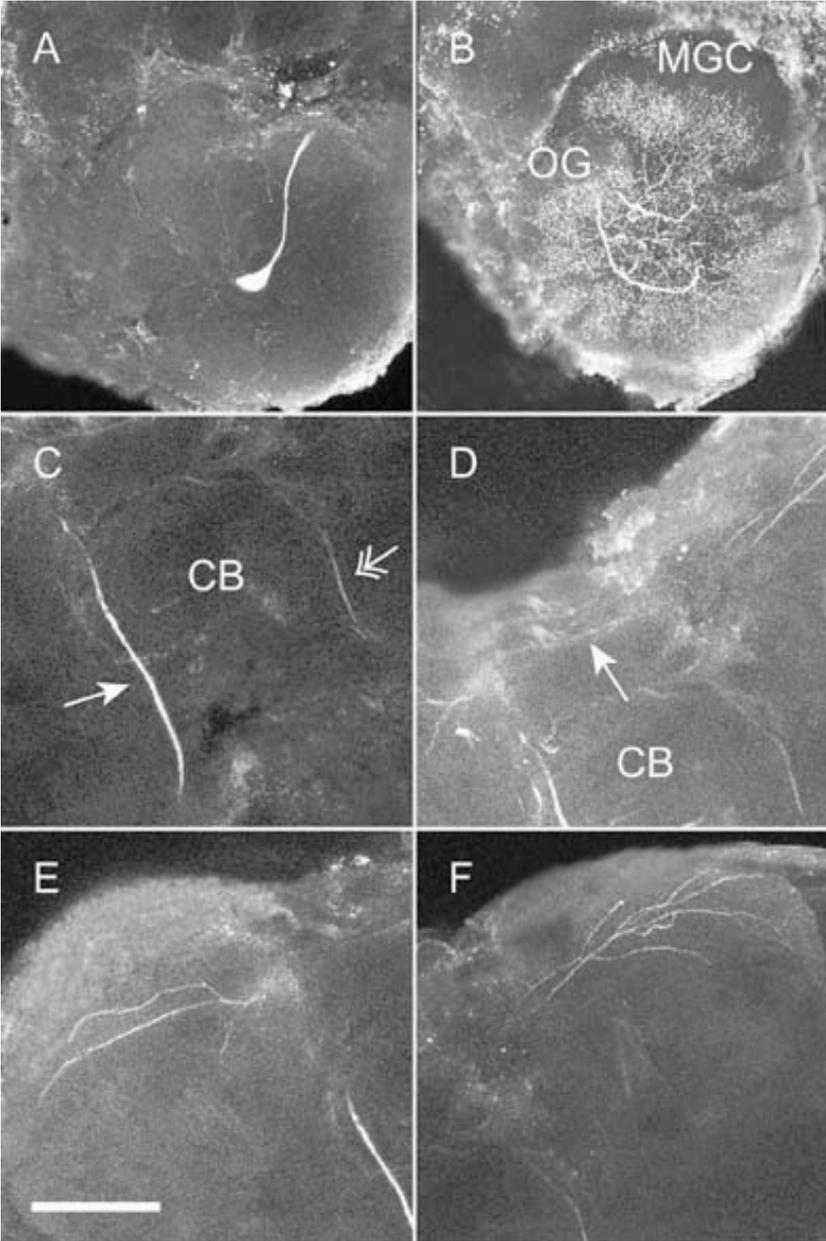
Christensen and Hildebrand 2002  
Curr Opin Neurobiol

## 免疫标记

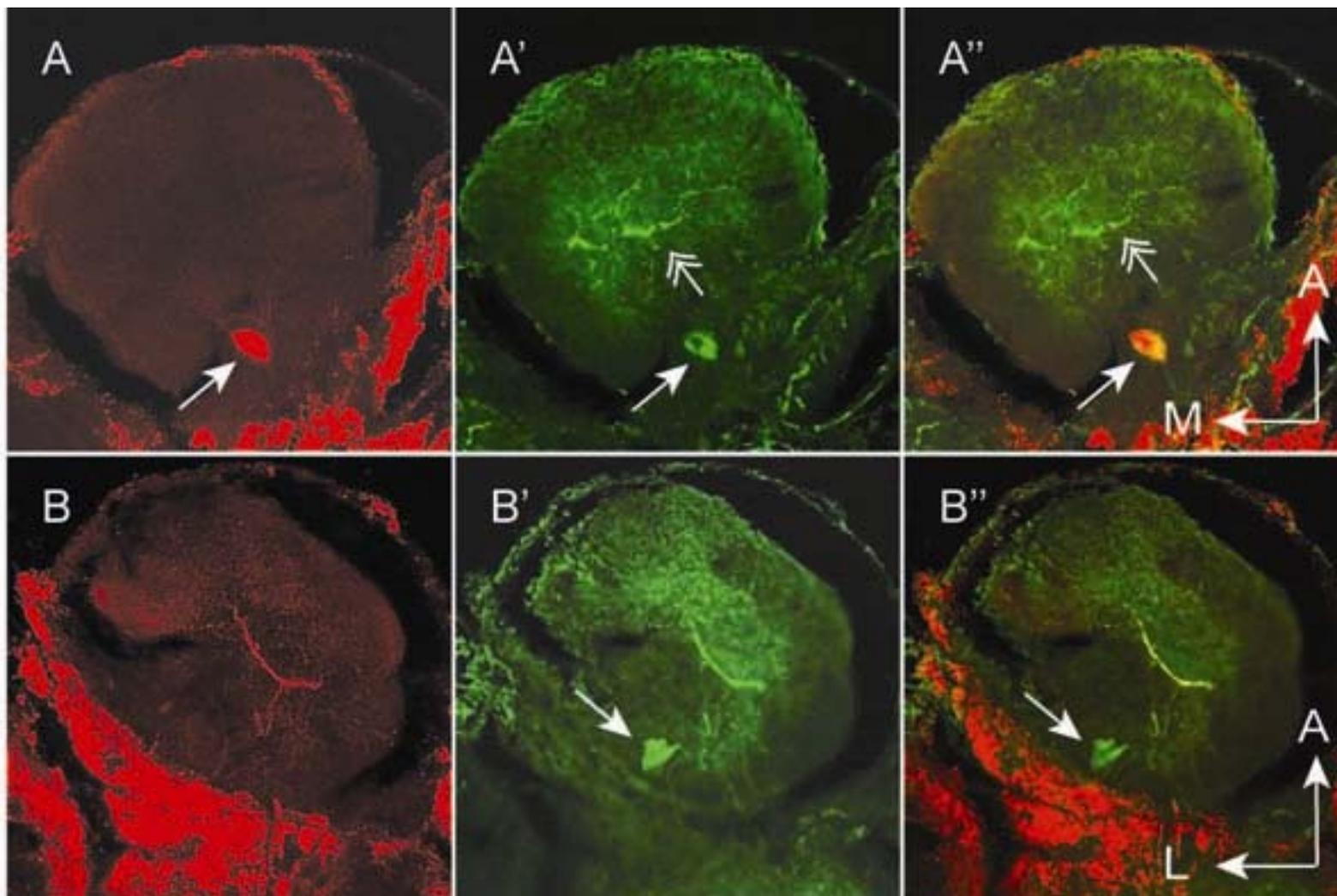


<http://upload.wikimedia.org/wikipedia/en/3/37/Immunohistochemicalstaining2.PNG>

细胞内染色

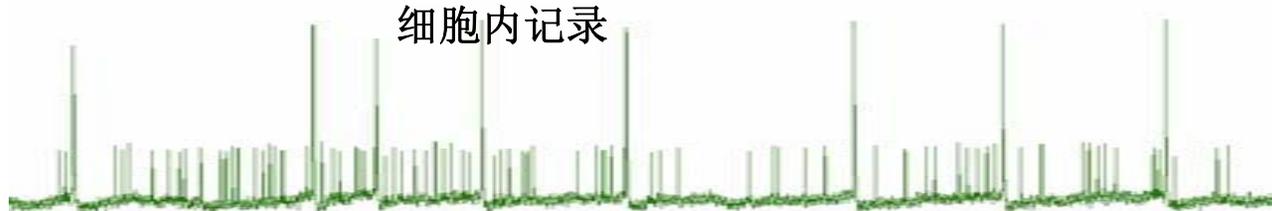


# 免疫标记

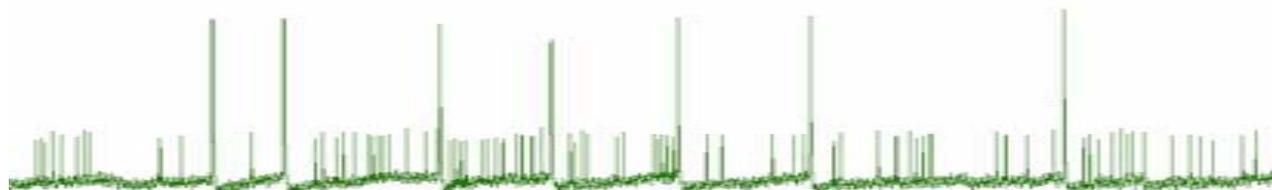


细胞内记录

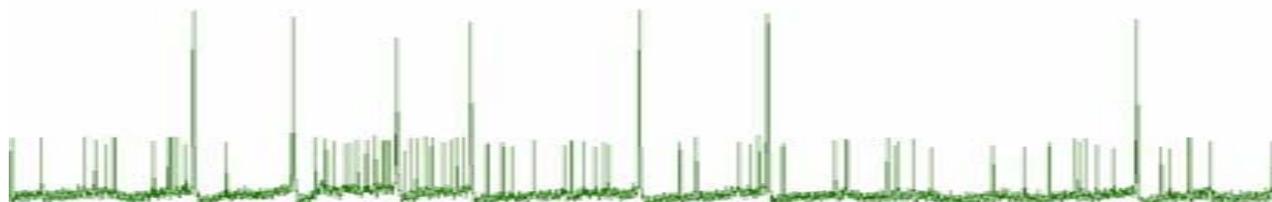
Z9-16:AL



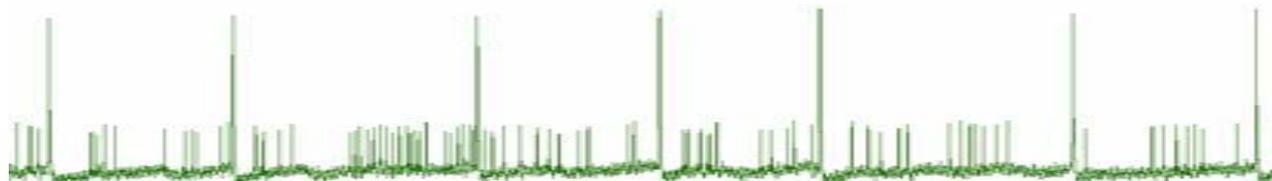
Z11-16:AL



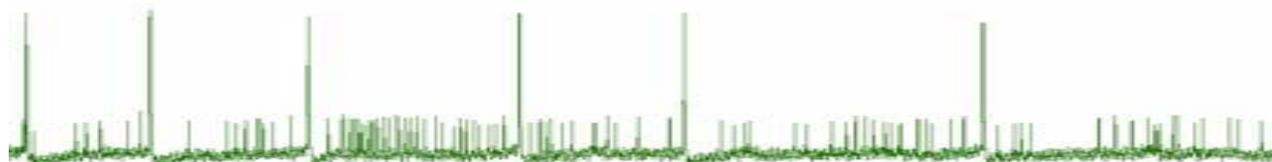
Z9-14:AL



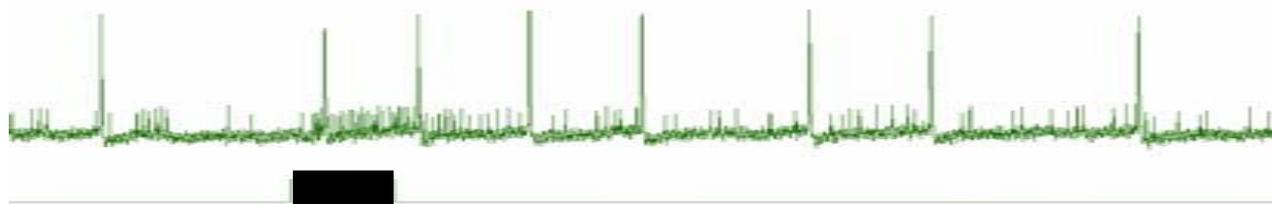
Z9-16:AL+  
Z11-16:AL

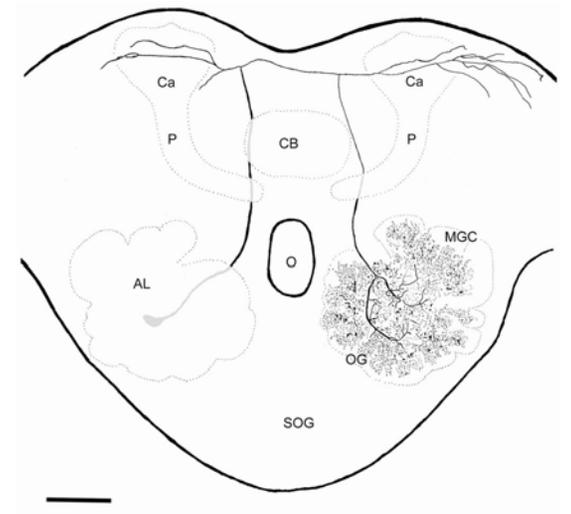
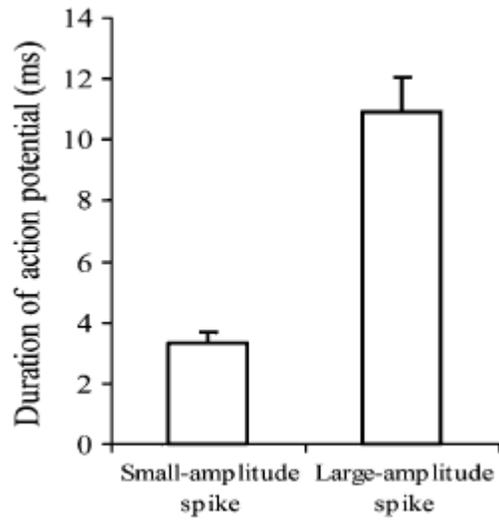
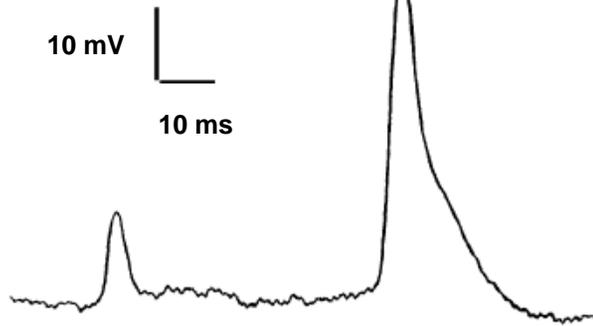


Z9-16:AL+  
Z11-16:AL

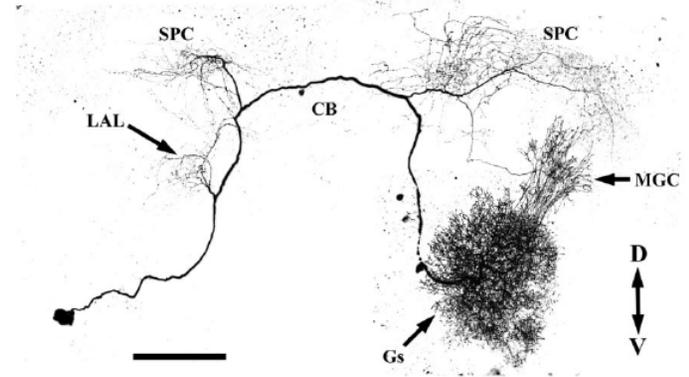
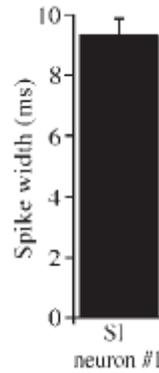
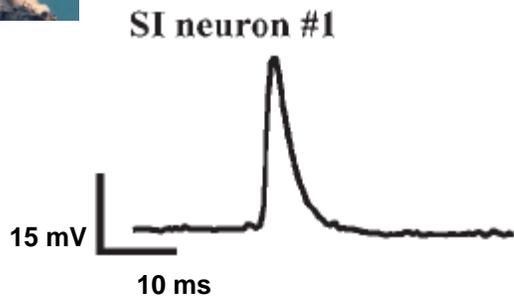


Ylang-ylang



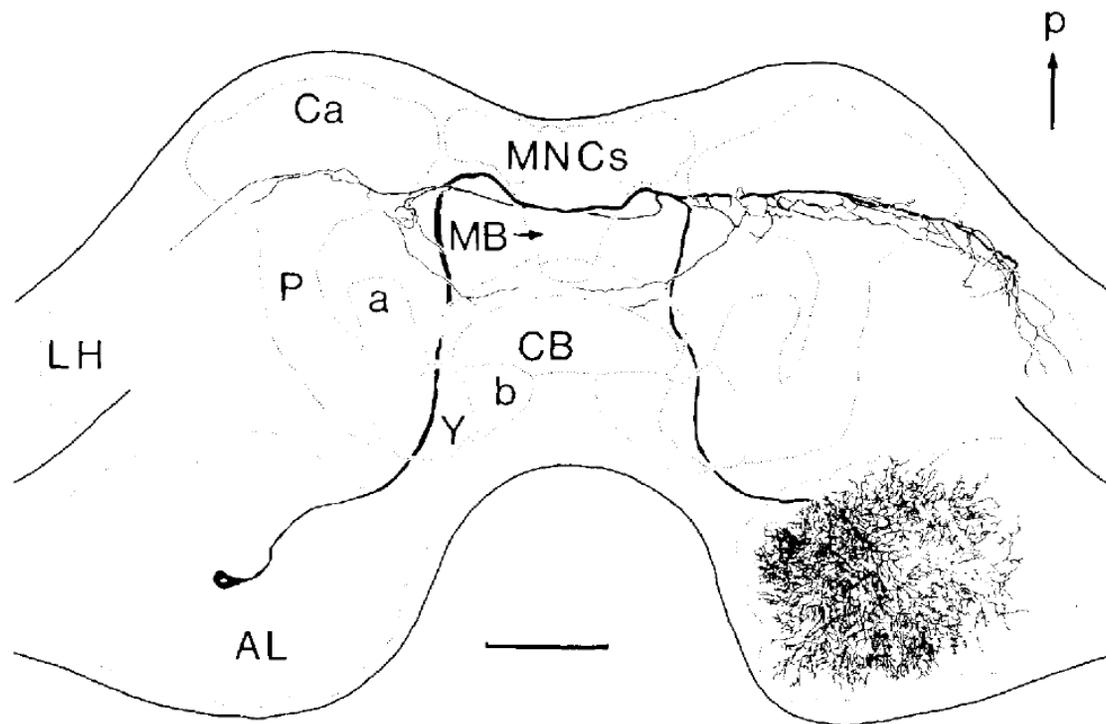


Zhao and Berg 2009 Chem Senses



Hill et al. 2002 Chem Senses

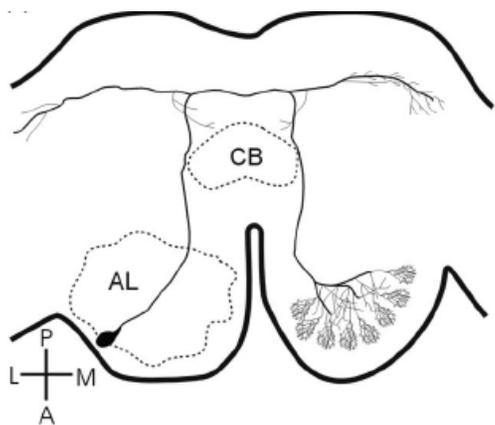
第一个被发现的昆虫触角叶内五羟色胺能神经元 (Kent et al. 1987 J Neurobiol)



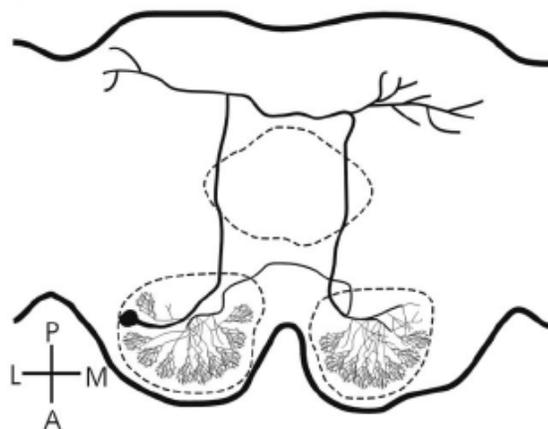
Sphinx moth, *Manduca sexta*



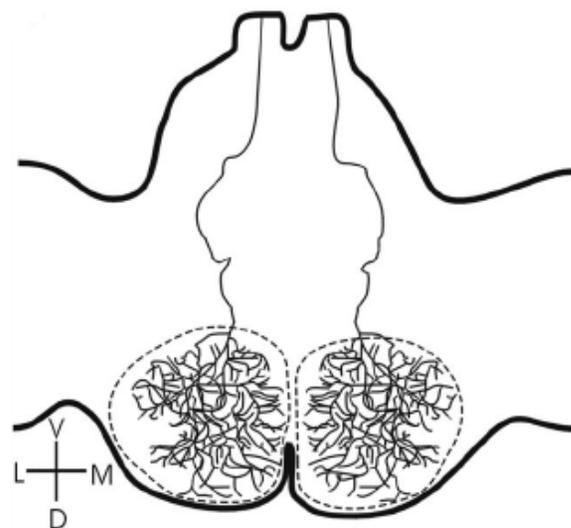
各种昆虫触角叶内五羟色胺能神经元 (Dacks et al. 2006 J Comp Neurol)



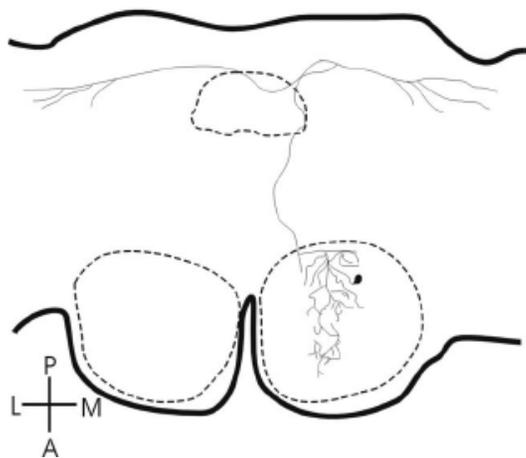
Moth, butterfly, beetle,  
lacewing, antlions



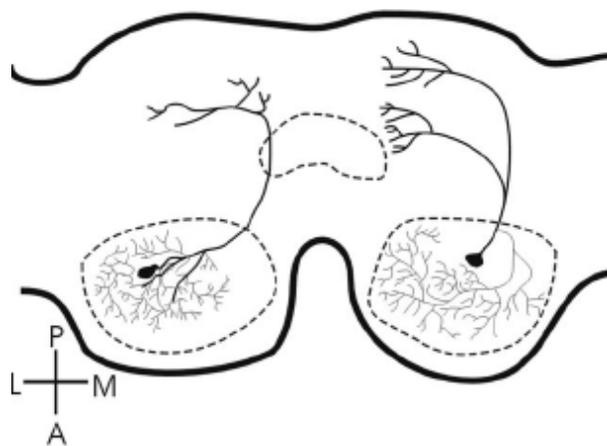
Fly



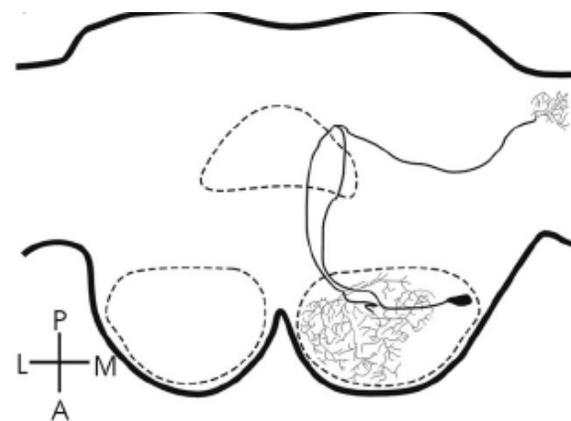
Honeybee, ant



Wasp

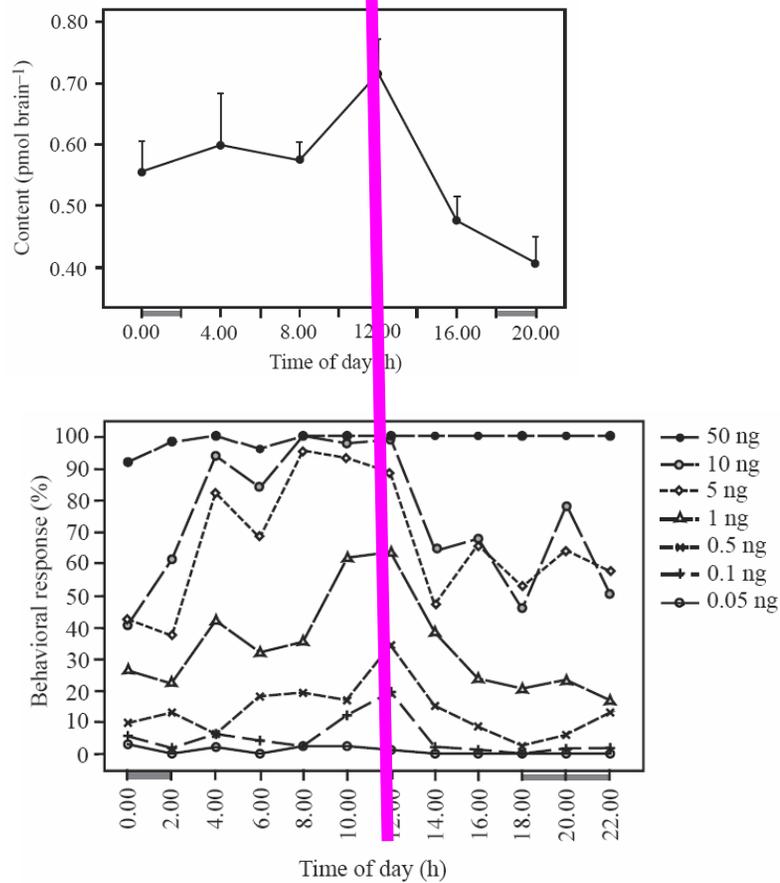


Bug



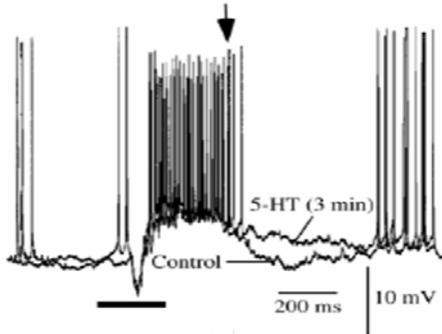
Cockroach, mantid

## 五羟色胺对昆虫嗅觉调节的证据：行为

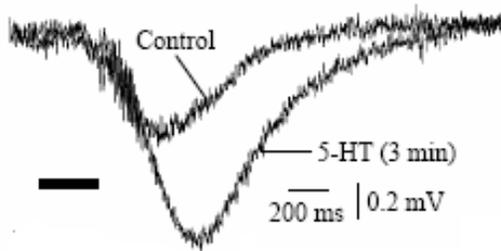


脑内五羟色胺节律变化与昆虫对性信息行为反应的节律变化一致 (Gatellier et al. 2004 J Exp Biol)

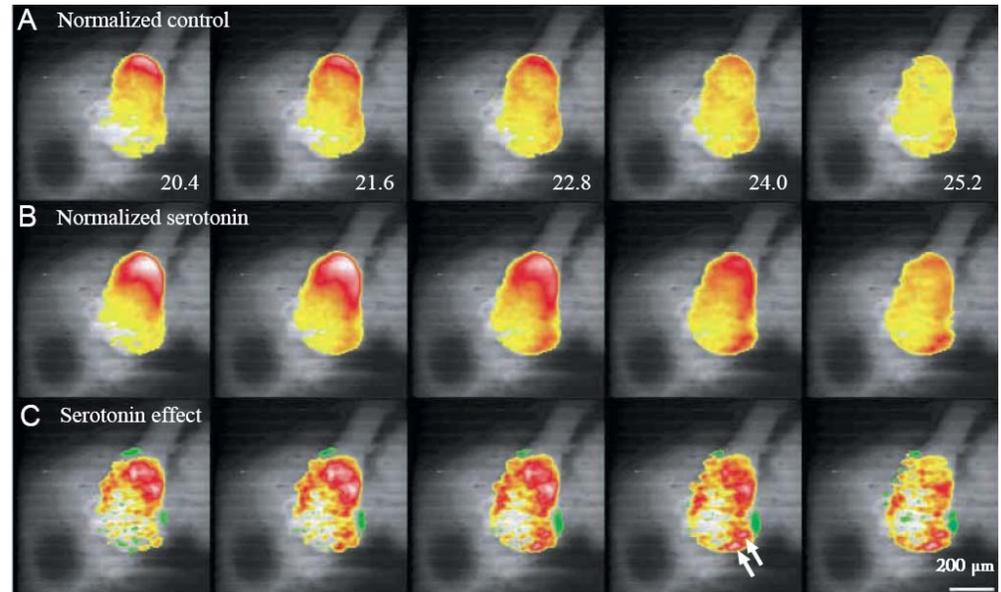
## 五羟色胺对昆虫嗅觉调节的证据：电生理



(Kloppenburg and Heinbockel 2000 J Exp Biol).



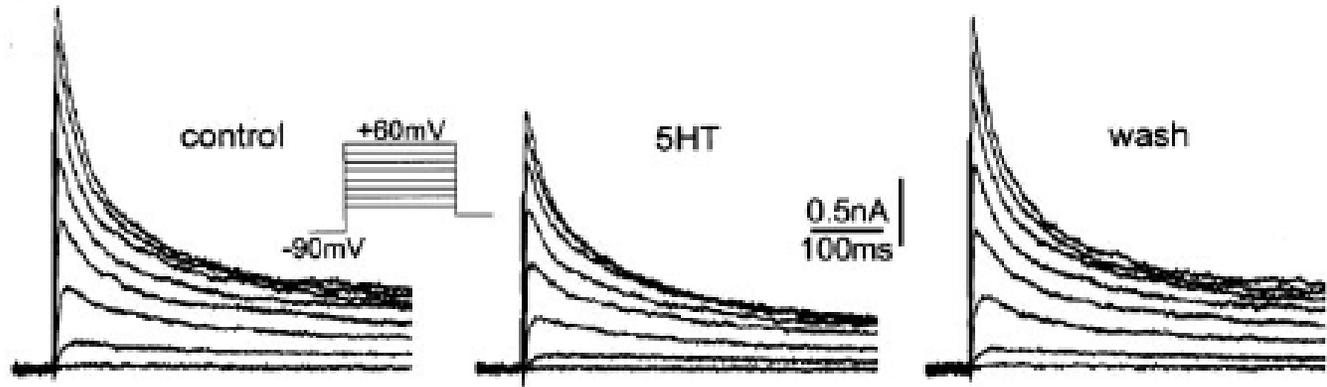
(Kloppenburg and Heinbockel 2000 J Exp Biol).



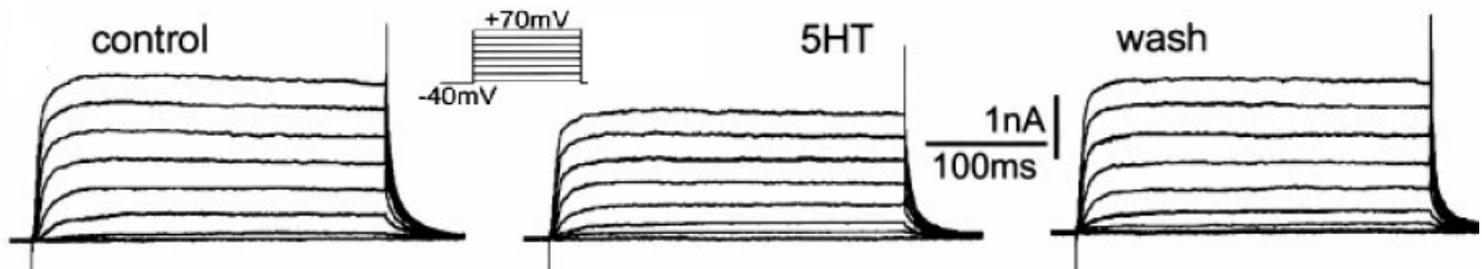
(Hill et al. 2003 J Exp Biol).

细胞外、细胞内记录和光影像记录证明**5HT**增强性信息素神经元对性信息素的反应。

## 五羟色胺对昆虫嗅觉调节的证据：膜片钳



transient K<sup>+</sup> current ( $I_A$ ) (Kloppenburg et al 1999 J Neurosci)



sustained K<sup>+</sup> current ( $I_{K(V)}$ ) (Kloppenburg et al 1999 J Neurosci)

五羟色胺作用于性信息素神经元上的两种钾离子通道。

触角叶内五羟色胺可能作用方式：五羟色胺作用于神经元上的**2种钾离子通道**，调节离子通道的通透性，调节神经元的动作电位的发放，进而调节神经元的兴奋性和反应敏感性，最终调节昆虫的行为反应。

昆虫触角叶内的五羟色胺能神经元到底有什么功能，对什么信号刺激有反应，与蛾子的性行为节律性是否有直接联系等等，这些问题还有待进一步的解答。细胞内记录这个神经元也许是个非常有用的方法和尝试。