calculate T5F and shell strength variance (data were transformed to natural logarithms). For each species and side of the shell, I calculated regression equations for breaking force as a function of foot area ($\Phi = 7 - 20$) and maximum tensile force as a function of foot area ($t = 8 - 23$). All brachiopod regression pairs were parallel (no statistically significant differences between the regression coefficients of each pair; smallest $P = 0.05$). Hence, the T5F's were essentially constant over the size ranges tested. Therefore, T5F = $\exp (S - lnT5F)$ where $S$ was the adjusted mean of the breaking force regression and $lnT5F$ was the adjusted mean of the maximum tensile force regression for each species and side of the shell. Shell strength variance equaled the residual variance ($MS_e$) of the breaking force versus foot area regressions. The MS_e's are reported as coefficients of variation (CV) where $CV = (MS_e/\Sigma Y)^{1/2}$. Clarke, J. Zool. (1977), 191, 241 (1980); R. C. Johnson, et al., J. Zool. 155, 141 (1966); S. Wright, Evolution and the Genetics of Populations (Univ. of Chicago Press, Chicago, 1968), vol. 1.

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14. For each point in Fig. 3, In T5F ± 1 standard error, and CV ± 1 standard error: C. digitalis A, 0.67 ± 0.145, CV ± 0.108; C. digitalis B, 0.50 ± 0.161, 0.36 ± 0.100; C. pella A, 0.46 ± 0.123, 0.50 ± 0.117; C. pella B, 0.20 ± 0.128, 0.20 ± 0.051; C. pella P, 0.15 ± 0.093, 0.22 ± 0.062; N. scutum A, 0.23 ± 0.086, 0.31 ± 0.054; N. scutum B, 0.08 ± 0.137, 0.27 ± 0.072; N. scutum P, 0.17 ± 0.102, 0.19 ± 0.050; A. mitra A, 0.66 ± 0.121, 0.33 ± 0.077; N. persona A, 0.21 ± 0.129, 0.31 ± 0.086; D. aspera A, 0.22 ± 0.134, 0.18 ± 0.047; A. R. P. as Fig. 3.

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of leaves along their midribs (Fig. 1D). An odor resembling fermented tea is produced by infected leaves. Insect species that characteristically pollinate the host plants are attracted to these wilted leaves (4), where they lick the mantle of conidia and become contaminated with spores (Fig. 1E). When these insects subsequently visit host flowers, the conidia are deposited on the stigmas, resulting in infected ovaries (mummy berries), and on other floral parts, to be further transmitted by additional pollinators. These short-lived (1) conidia require insects as vectors. When we bagged 400 hand-pollinated flowers of a blueberry plant on branches also bearing infected leaves, with fiberglass screening to exclude most insects but not wind, 10 percent mummified fruit was produced; whereas similarly infected, unbagged, open-pollinated branches of the same plant, at the same height, bore 63 percent mummified fruit.

The ratio of infected, wilted leaves to blossoms varies seasonally, according to rainfall, and is highest on low branches overhanging moist ground where aphodcia are numerous. During their search for blossoms, insects are attracted to infected leaves in sun or shade at rates of 3 to 24 (x = 9) visits per hour (4). Their approach to wilted leaves, alighting, and search patterns (76 observations) resemble tactics used when encountering host flowers—for example, they zigzag, usually making upward search flights, and alight atop objects (petioles of wilted leaves or calyces of flowers); they walk in rotation while seeking food, bringing the insect beneath the flower or in contact with conidia on the leaf; and they lick, ingesting floral nectar or conidia. We did not see bees make pollen-collecting motions when encountering conidia. They and the other vectors were never seen licking healthy leaves, petioles, and midribs. Although some varieties of Vaccinium have extranoral nectaries on leaf margins, visits to such nectaries were not seen at the study site. Analysis by thin-layer chromatography of the conidial mantle, where most licking occurs, revealed that sucrose, glucose, and fructose are present. Nectaries of Vaccinium contain about 20 percent sucrose and 80 percent glucose and fructose (7).

In daylight, the wilted leaves do not visually resemble the host’s white, yellow, and pink flowers; however, the pollinators behave as if they are visiting nectar-yielding flowers. Investigation (8) of discolored areas of infected leaves that appear brown to violet in daylight showed that these areas reflect ultraviolet light at 300 to 400 nm (Fig. 1F). Blueberry floral calyces are also ultraviolet-reflective, and they and infected leaves visually contrast with healthy, ultraviolet-absorbent (9) surrounding leafy vegetation. Thus, the Monilinia-infected, discolored leaves evidently mimic the flowers of their host in yielding sugary rewards to the pollinator vectors and, to some extent, in providing them with ultraviolet-reflective patterns analogous to nectar guides.

Flowers of certain orchids and other vascular plants may falsely attract pollinators (10). The Vaccinium (or Gaylussacia)-pollinator-Monilinia complex is unusual because host-pollinator mutualism is exploited by host-specific and vector-dependent pathogens, which achieve their necessary dissemination and survival by causing “deceitful” floral mimicry (11).

LEKH R. BATRA
Mycology Laboratory,
U.S. Department of Agriculture,
Beltsville, Maryland 20705

SUZANNE W. T. BATRA
Systematic Entomology Laboratory, U.S. Department of Agriculture, Beltsville

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4. We isolated cultures from conidia removed from the following pollinator species and from stigmas visited by them, observed them contacting conidia on wilted leaves, and observed them entering host flowers immediately after contacting conidia (V, on Vaccinium; G, on Gaylussacia). Hymenoptera: Nomada lateola (V); N. bishops* (V and G); N. articulata (V); N. ovata (V and G); Andrena spp. * (V and G); Andrena carlini (V and G); A. victima (V and G); Dialictus sp. (V); Augeochlora pura (V); Sphecodes sp. (V); and Camponotus pentaventriculus (V and G). Diptera: Epalpus signifer (V and G) and Empididae sp. (V). Lepidoptera: Thyris lugubris (V and G) and Erymis horatius (V and G). The fly, Dasyphora cyanicolor, was the only nonpollinator attracted to conidia (G). Pollinators not seen contacting conidia included the following: Hymenoptera: Euryelus sp. (V); Andrena pruni (V); Ceratina dupla (V); Xylocopa virginica (V) and Bombus sp. (V). Diptera: Bombyliidae sp. (V and G). The asterisk indicates the more prevalent visitors at this study site. Visits to wilted leaves were consistently fewer than floral visits (about 10 to 20 flower visits observed per leaf visit).
5. L. W. Boulanger, G. W. Wood, E. A. Osgood,
Intracellular Stimulation of an Identified Neuron Evokes Cardioacceleratory Peptide Release

Abstract. The central nervous system of the tobacco hawkmoth, Manduca sexta, is known to contain two cardioacceleratory peptides (CAP's), both of which function in vivo as cardioacceleratory neurotransmitters. Intracellular electrical stimulation of a single abdominal ganglion neuron evokes the release of CAP-like bioactivity. This stimulation-evoked bioactivity is destroyed by prior treatment with protease. The possibility that intracellular stimulation of a CAP-containing neuron synaptically activated additional spiking neurons is eliminated.

Neuropeptides in the central nervous system (CNS) are capable of acting as neurotransmitters (1–3) and as neurohormones (4–6). It is often easier to define a role for a neuropeptide if that neuropeptide can be unequivocally associated with an identifiable neuron or neurons. There are several physiological, anatomical, and pharmacological criteria that must be met before a neuropeptide can be established as a neurochemical mediator at the cellular level (7). Most of these criteria are similar to those for the rigorous identification of conventional neurotransmitters (8). One crucial criterion frequently overlooked is the demonstration that the neuropeptide is released when the putative peptidergic neuron is individually depolarized above threshold. Although peptide release from the CNS has been shown in several preparations by treatment with K+ -rich saline (9–11) or by electrical stimulation of peripheral nerve roots (12–14), it has been difficult to demonstrate peptide release resulting from the activity of single cells regardless of whether the neuropeptide is acting as a neurotransmitter or as a neurohormone. We show here that intracellular electrical stimulation of a single, identified neuron is sufficient to elicit the release of neuropeptide activity from its terminal endings.

We have studied the cardioacceleratory peptide (CAP) system in the tobacco hawkmoth, Manduca sexta. Earlier investigations (15–17) have shown that two cardioactive neuropeptides, known as cardioacceleratory peptide 1 (CAP1) and cardioacceleratory peptide 2 (CAP2), are present in the pharate adult ventral nerve cord (VNC). The two CAP's are coreleased into the hemolymph from the segmentally repeated transverse nerves (Fig. 1B) immediately after adult emergence, and they act to increase heart rate significantly and to facilitate inflation of

![Figure 1](https://example.com/figure1.png)

**Fig. 1.** Stimulation of a new MB neuron causes the release of CAP-like bioactivity. (A) Camera lucida drawing of a new MB neuron in a late adult abdominal ganglion. We stained the cell by passing positive current through an intracellular micropipette filled with 40% hexamine cobaltous chloride. In the preparation a modification of Timm's silver intensification procedure was used (23). The bifurcating axon exits the ganglion via both ventral nerves. The cell terminates bilaterally in neurosecretory endings along the length of the transverse nerve (24). (B) Diagrammatic representation of the experimental protocol. We impaled a soma of a new medial bilaterally projecting (MB) cell, using standard glass microelectrodes, and depolarized it by passing d-c current pulses for up to 15 minutes at a frequency of not greater than 0.5 Hz. Although not visible in situ, each new MB cell was identified unequivocally on the basis of its cell body position in the ganglion, the trajectory of its axons, and the characteristic electrical properties of its soma. As is typical of insect neurosecretory cells (24, 25), the somata of the new MB neurons were electrically excitable, capable of supporting overshooting action potentials with durations of approximately 50 msec. Thus, as a group these neurons were uniquely recognizable during recording sessions. As it proved impossible to maintain somatic activity of dye-filled microelectrodes, we were unable to distinguish between the two anteriormost pairs of new MB cells. We collected CAP activity by erecting a Vaseline well (volume ~0.1 ml) around the transverse nerve at a point distal to the transverse nerve–ventral nerve anastomosis. The contents of the well were collected at various times, frozen on Dry Ice, and stored at −20°C, usually for less than 24 hours, until bioassayed for CAP activity. Abbreviations: TN, transverse nerve; DN, dorsal nerve; VN, ventral nerve; MN, median nerve. (C) Cardioacceleratory activity of samples collected during intracellular stimulation of a new MB cell. Each sample was sequentially bioassayed on the same in vitro Manduca heart as described (16, 17, 21). For these experiments, the variability in the basal heart rate was ±1 percent. Arrows denote application of samples. The heart rate increased after application of the Stim sample. A standard lepidopteran saline (16) was used in all experiments.

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