

## SEROTONIN AND NOREPINEPHRINE IN PLANT TISSUES

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A VARIETY of substances which participate in neural transmission in animals have also been found in plants. Acetylcholine has been found in *Phaseolus multiflorus*,<sup>1</sup> moss callus,<sup>2</sup> *Albizia julibrissin*<sup>3</sup> and in *Pisum sativum*;<sup>3</sup> serotonin in a wide variety of plant tissues;<sup>4,5</sup> and norepinephrine in bananas<sup>5</sup> and *Hydrastis canadensis*.<sup>6</sup> The distribution of the latter two substances is the subject of this present investigation.

The results are presented in Table 1. With the exception of *Mimosa pudica*, every plant tested contains both serotonin and norepinephrine. The organs of movement, the pulvini and tendrils, generally show the largest concentrations of these amines, with *Phaseolus multiflorus* an obvious exception. At present, the role of these substances in plants is not known and it is possible that they may only be intermediate products of synthetic or degradation pathways.

### EXPERIMENTAL

With the exception of *Passiflora quadrangularis*, which was grown from cuttings in a greenhouse, all plants were grown from seed and raised as previously described.<sup>3</sup> Tissue was excised in the light (except for etiolated *Pisum*), quickly frozen and homogenized. The plants were extracted and assayed for serotonin and norepinephrine by the fluorometric method of Welch and Welch<sup>7</sup> which is quite specific,<sup>8,9</sup> gives good recoveries and is highly reproducible. Determinations were in triplicate. Verification that the assay was specific for plant tissues was obtained by using the clam heart assay for serotonin<sup>10</sup> on *Albizia* laminae and a different extraction procedure for norepinephrine<sup>11</sup> on *Mimosa* primary pulvini. Results of these assays produced estimates similar to those presented on p. 192 in Table 1 (*Albizia* laminae 4 µg/g tissue, *Mimosa* pulvini 2 µg/g tissue).

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<sup>4</sup> V. ERSPAMER, *Handbook of Experimental Pharmacology* **19**, 132 (1966).

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<sup>6</sup> T. P. WAALKES *et al.*, *Science* **127**, 648 (1958).

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<sup>9</sup> P. A. SHORE and J. S. OLIN, *J. Pharm. Exper. Therapeutics* **122**, 295 (1958).

<sup>10</sup> B. M. TWAROG and I. H. PAGE, *Am. J. Physiol.* **175**, 157 (1953).

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TABLE 1. CONCENTRATIONS OF SEROTONIN AND NOREPINEPHRINE

Species and age	Plant part	Mean amount $\mu\text{g/g}$ fresh tissue	
		Serotonin †	Norepinephrine †
<i>Mimosa pudica</i> (24 months)	Primary pulvini	*	3.5
	Pinnae	*	*
	Petioles	*	0.6
<i>Albizzia julibrissin</i> (13 months)	Secondary pulvini	4.7	4.6
	Laminae	2.7	2.8
	Rachillae	3	3.4
<i>Phaseolus multiflorus</i> (14 days)	Pulvini	0.6	0.6
	Laminae	1	0.6
	Petioles	1	0.6
<i>Samanea saman</i> (11 months)	Secondary pulvini	4	8.3
	Laminae	0.1	0.5
	Rachillae	2	5
<i>Pisum sativum</i> (14 days, light)	Tendrils	0.9	1.8
	Laminae	*	1
	Stems	1	0.8
(6 days, dark)	Hooks and internodes	0.6	0.3
	Terminal buds	*	0.3
<i>Passiflora quadrangularis</i> (8 months)	Tendrils	1	0.3
	Laminae	*	*

\* If present, less than 0.06  $\mu\text{g/g}$  fresh tissue.

† Standard deviation for all cases, less than 15% of the values reported.