

Table I. The feeding responses of 20 3rd instar *Heteronychus arator* larvae and adults to carbohydrates tested at a concentration of 0.1 M

Test chemical	Total faecal pellets produced	
	Larvae	Adults
<b>Pentoses</b>		
Arabinose	168	47
Rhamnose	140	28
Xylose	206	32
<b>Hexoses</b>		
Fructose	474	464
Glucose	423	527
Galactose	287	19
Mannose	236	23
Sorbose	246	31
<b>Disaccharides</b>		
Maltose	894	588
Sucrose	570	362
Trehalose	302	35
Cellobiose	193	42
Melibiose	161	—
<b>Tri- and polysaccharides</b>		
Melezitose	253	40
Raffinose	128	68
Starch (0.1%)	217	20
Starch (1.0%)	484	127
<b>Polyhydric alcohol</b>		
Dulcitol	109	56
Blank	152	7

Table II. The feeding response of 20 3rd instar *Heteronychus arator* larvae to 0.1 M sucrose, 0.1 M maltose and 0.01 M ascorbic acid and to combinations of these

Test chemicals	Total faecal pellets produced
Sucrose	563
Sucrose + ascorbic acid	652
Maltose	901
Maltose + ascorbic acid	587
Ascorbic acid	285
Blank	142

At other concentrations maltose was less active: groups of 20 larvae offered discs containing the sugar at 0.001 M, 0.01 M, 0.1 M and 1.0 M concentrations produced 186, 492, 743 and 139 faecal pellets respectively. Adult beetles failed to respond to the majority of the test sugars. Only sucrose, fructose, glucose and maltose induced sustained feeding, but again maltose provoked the strongest response.

An earlier study<sup>4</sup> on the feeding behaviour of larvae of another scarab, *Costelytra zealandica*, showed that the response to the most active sugar, sucrose, was greatly enhanced by the addition of 0.01 M ascorbic acid, although on its own the acid had little effect on ingestion. Black beetle larvae, too, fed more vigorously on medium incorporating both these nutrients than on sucrose alone (Table II). But the addition of ascorbic acid to test discs containing maltose diminished rather than enhanced the insects' response to the sugar.

The response of *H. arator* larvae and adults to maltose is unusual. The sugar has commonly been mentioned as a phagostimulant for phytophagous insects but in only one earlier instance has it been found more effective than sucrose<sup>5</sup>. We have no explanation for the particularly strong response of black beetle larvae and adults to maltose. Starch can, however, be considered as being composed of a number of units of maltose and the response to it is therefore consistent with that to maltose.

We are glad to report that incorporation of maltose into the standard artificial diet rendered it much more acceptable to *H. arator* and the insects now feed more vigorously on it (PRITAM SINGH, personal communication).

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<sup>5</sup> S. R. LOSCHIAVO, Ann. Am. ent. Soc. 58, 576 (1965).

## Anthelmintic Activity of Albendazole Against Liver Flukes, Tapeworms, Lung and Gastrointestinal Roundworms

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**Summary.** A new derivative, albendazole, of the benzimidazole group of anthelmintics which is active against nematode, cestode and trematode species, was found.

This article reports the discovery of a new anthelmintic with outstanding potency and spectrum of activity against liver flukes, tapeworms, and both lung and gastrointestinal roundworm infections. Albendazole is methyl [5-(propylthio)-1H-benzimidazol-2-yl]carbamate and has the chemical formula C<sub>12</sub>H<sub>15</sub>N<sub>3</sub>O<sub>2</sub>S (Figure).

Albendazole is prepared from 4-*n*-propylthio-*o*-phenylenediamine and carboxymethylcyanamide. It is a stable, white, odorless powder melting at 214–215°C with de-

composition. It is insoluble in water and is only slightly soluble in most organic solvents.

A single dose of 2.5–10 mg/kg administered orally to sheep and cattle naturally or artificially infected eliminated 94–100% of *Haemonchus*, *Ostertagia* and *Trichostrongylus* in the abomasum; and *Strongyloides*, *Nematodirus*, *Cooperia*, *Bunostomum*, *Trichostrongylus*, *Capillaria*, *Oesophagostomum* and *Chabertia* in the small and large intestines. *Trichuris* was reduced by 85% at 10 mg/kg.

In controlled experiments with sheep and cattle artificially infected with larvae of lung nematodes of the genus *Dictyocaulus*, a single oral dose of 5 mg/kg eliminated 84–100% of the worms. In sheep naturally infected with tapeworms of the genus *Moniezia*, a single oral dose at 10 mg/kg reduced the worm burden by 100%.

Albendazole was administered orally at 10 mg/kg to sheep artificially infected with metacercariae of *Fasciola hepatica* after the infection was determined to be patent. The activity was excellent, with 99% of the flukes being eliminated.

Preliminary experiments also indicate that comparable low doses are effective against *Ascaris*, *Oesophagostomum* and *Trichuris* in pigs; small and large strongylid worms, *Oxyuris*, *Parascaris* and *Probstmayria* in horses; *Ascariidia* and *Heterakis* in chickens.

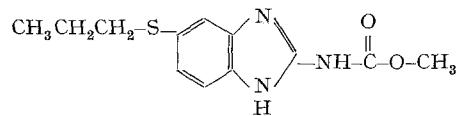
Mice were infected orally with 50,000 embryonated ova of *Ascaris suum* per day for 2 days. Albendazole fed prophylactically for 11 days at 0.05% of the diet protected the mice against the lethal effects of the migrating larvae.

In a preliminary experiment in dogs, a single oral dose of 250 mg/kg was extremely active against *Toxocara canis*

but was only slightly active against *Ancylostoma caninum*. However, administration at 50 mg/kg for 3 days was fully effective against these worms.

The oral LD<sub>50</sub> in rats of albendazole was determined to be 2.40 g/kg with 95% confidence limits of 1.55 to 3.25 g/kg. No untoward effects were observed in sheep dosed orally with up to 100 mg/kg. However, a single dose of 500 mg/kg was not tolerated. Further studies, delineating the toxic and teratogenic potential of the compound are underway.

This is the first reported anthelmintic which promises to have useful activity against all the types of helminth parasites menacing our domestic animals. Extensive investigations are now under way around the world to fully evaluate its safety and field efficacy.



Methyl [5-(propylthio)-1H-benzimidazol-2-yl]carbamate.

## Chromatin Subunits Visualized in Common Ultrathin Sections of *Helianthus* Nuclei

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**Summary.** Nuclei of etiolated hypocotyl cells of the sunflower (*Helianthus annuus* L.) display chromatin subunits of 110 Å diameter in untreated ultrathin sections, because of spontaneous and extensive chromatin decondensation.

Eukaryotic chromatin is organized in the form of a repeating subunit structure: Histone octamers<sup>2-4</sup> are associated with some 200 base pairs of DNA forming the so-called *v*-bodies<sup>5</sup> or nucleosomes<sup>6</sup>; the single subunits are connected by DNA segments free of histones. Thus, the appearance of beads on a string arises, when chromatin is prepared in appropriate manner<sup>7-12</sup>. Although nucleosomes have been demonstrated by various biophysical, biochemical and electron microscopic techniques to occur in all eukaryotic organisms, such as fungi, plants and animals<sup>7-16</sup>, they were not yet shown in ultrathin sections prepared for common transmission electron microscopy.

**Material and methods.** Seeds of *Helianthus annuus* L. var. Russian Mammoth were germinated in the dark. Parenchyma cells of the hypocotyl cortex were fixed in glutaraldehyde (1%, pH 7.3) for 2 h, post-fixed with osmium tetroxide (1%) for 1 h, and block-stained with uranyl-acetate during dehydration<sup>17</sup>. Embedding was made according to SPURR<sup>18</sup>. Ultrathin sections were made with a Reichert OmU<sub>3</sub> ultramicrotome and micrographed with a Zeiss EM 10 electron microscope at 60 kV.

**Results.** The nuclei of etiolated hypocotyl cells of the sunflower are characterized by an extensive chromatin decondensation. This decondensation probably substitutes somewhat the pretreatment of chromatin with 10% formalin, that was used to reveal nucleosomes, e.g. in whole mount metaphase chromosomes<sup>12</sup>. As a result, a clear subunit structure is visible in ultrathin section without any pretreatment (Figure). The unravelling of the chromatin fibres is, however, not sufficient to give rise to

the appearance of beads on a string, i.e. to reveal the histone-free DNA segments between the nucleosomes. Some portions of the chromatin, probably chromomeres and heterochromatin, display a denser packaging of the subunits than does the gross of the nucleus. The diameter of the single particle is, on an average, 110 Å.

<sup>1</sup> Acknowledgment. I thank Mrs. S. KÜHNER for careful technical assistance.

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