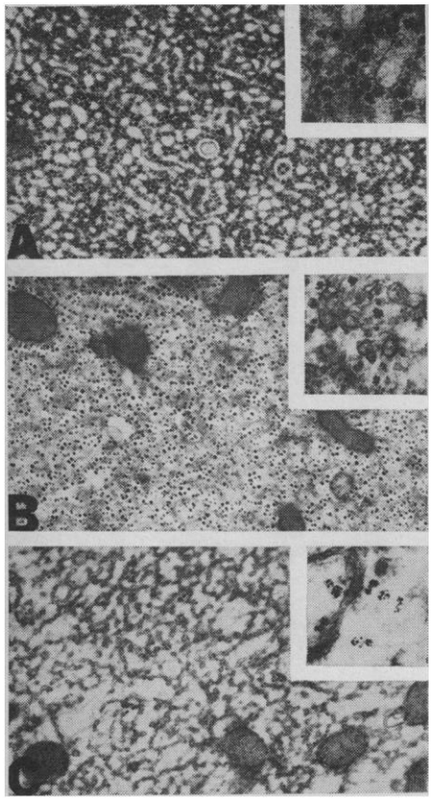

Fig. 1. Sections of liver from *Amphiuma means tridactylum* showing depletion of glycogen during induced anoxia. (*A*) From control; (*B*) from animal subjected to anoxia for 3 hours; (*C*) from animal subjected to anoxia for 6 hours (× 5400; inserts, × 40,000).

a mean of 29 (18 to 35) subunits per rosette in the control animals; 15 (10 to 30) subunits per rosette in the animals exposed to anoxia for 3 hours; and 9.3 (3 to 16) subunits per rosette in the animals exposed to anoxia for 6 hours. If these subunits are subsequently found to be normal facets of each glycogen unit, then they are probably the smallest visible particles converted to glucose.

The smooth endoplasmic reticulum is generally considered to be a channeling network, since it is best developed when the cell is actively secreting some substance, for example, during salt secretion from the gills of fish (*4*). During storage periods one would expect the endoplasmic reticulum to be less developed than during periods of utilization of the storage product. Greater development of the endoplasmic reticulum during anoxia is probably a response by the cell to more effectively mobilize glycogen out of the liver.

Glycogen is generally considered a quick energy reserve in mammals; however, when there is complete absence of oxygen, death probably ensues before hepatic glycogen is mobilized. That some reptiles and amphibians can utilize stored glycogen during anoxia more effectively than others suggests that glycolysis may play a more predominant respiratory role in these animals than in mammals.

Amphiuma means tridactylum in southern Louisiana are collected from sewage and swampy ditches—areas of low oxygen tension. Many of these ditches dry out during the summer and the *Amphiuma* go underground to avoid dessication. Under these conditions the animals lower their metabolic rate and rarely use pulmonary respiration (*5*).

Stored lipid is at a minimum during the summer months; even during periods of maximum storage the amount stored is extremely low (*5*), yet *Amphiuma* can withstand starvation for extended periods (*6*). Thus glycogen may be a long-term storage product in *Amphiuma*, as in some molluscs, and may serve as a lipid substitute, since the oxidation of fats requires more oxygen per gram than the oxidation of glycogen. In a habitat of low oxygen tension, glycogen would have a definite advantage over lipid as a storage product. Possibly a balance exists between the energy derived from glycolysis and the small amount of aerobic energy that allows these animals to sustain themselves during extended droughts. The low metabolic rate during unfavorable conditions would also be a sustaining factor.

FRANCIS L. ROSE
Department of Zoology, Tulane University

JOSEPH ZAMBERNARD
Department of Pathology, University of Colorado Medical School, Denver

GILBERT S. POGANY
Department of Zoology, Tulane University, New Orleans, Louisiana

References and Notes

1. J. H. Luft, *J. Biophys. Biochem. Cytol.* **9**, 409 (1961).
2. E. S. Reynolds, *J. Cell Biol.* **17**, 208 (1963).
3. J. P. Revel, *J. Histochem. Cytochem.* **12**, 104 (1964).
4. C. W. Philpott and D. E. Copeland, *J. Cell Biol.* **18**, 389 (1963).
5. F. L. Rose, in preparation.
6. W. E. Brode and G. Gunter, *Science* **130**, 1758 (1959).
7. Supported in part by NIH fellowship (1 F1 GM-20, 096-01) and a grant from the Society of the Sigma XI to F.L.R. We thank Eugene Copeland, Harold Dundee, Milton Fingerman, Gerald Gunning, Austin Fitzjarrell, Jean P. Revel, and Franklin Sogandares-Bernal for assistance during the preparation of this report.

29 January 1965

Kinin-Induced Parthenocarpy in the Fig, Ficus carica L.

Abstract. *Parthenocarpic Calimyrna fig fruits induced with a kinin were identical morphologically to those previously produced parthenocarpically with auxin or gibberellin. Thus, the three types of endogenous hormones thought to originate in the seeds and to stimulate directly fruit growth can be supplied by plant parts other than seeds.*

Kinins occur naturally in a number of fruits (*1, 2*). Although they have been implicated in the cell division phase of fruit growth (*2*), it is not known whether they actually govern this type of growth. Weaver and van Overbeek (*4*) reported that Black Corinth grape clusters dipped in a kinin solution 4 days after anthesis produced berries about three times as large as untreated berries. Since no histological studies were made, it is not known whether the increase in berry size was due to stimulated cell division or cell enlargement, or both. Kinins have not heretofore been reported to induce parthenocarpy. However, the synthetic kinin SD 8339 (*4*), having the structural formula shown in Fig. 1, has proved very effective for promoting parthenocarpy in the Calimyrna fig.

At concentrations of 100 and 500 parts per million, SD 8339 was applied in aqueous solution by spraying the young syconia and foliage or by injecting the fruit with a hypodermic syringe, the needle being passed through the ostiole and into the central cavity which was then filled with 1 to 2 ml of the solution. Three to four fruits on each of five trees were used for each treatment. At the time of treatment, the female flowers within the syconia were receptive to pollination. Cross-pollination was prevented by covering the branches bearing the fruits to be treated with muslin bags. The bags enclosed the branches for about 2 weeks, the period during which pollination of unbagged fruits by the insect *Blastophaga psenes* took place. Bagged but untreated fruits served as controls. Unless cross-pollination occurs or the syconia are treated with certain growth regulators (*5*), they cease growth and wither, and abscission occurs in about 2 weeks.

As shown in Table 1, SD 8339 was very effective for inducing parthenocarpy, particularly when injected into the syconia. After spraying with SD

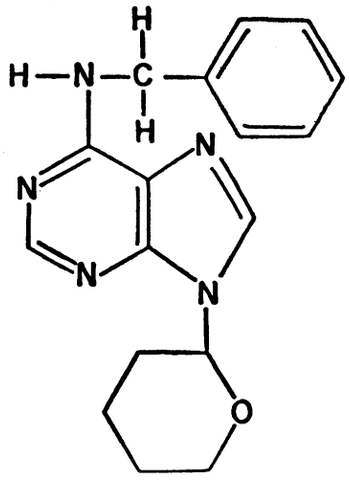

Fig. 1. Structure of SD 8339, 6-(benzylamino)-9-(tetrahydropyran-2-yl)-9H-purine.

8339, the initial percentages of fruit set were high, but the growth of a number of fruits subsequently ceased and abscission occurred before they reached maturity. In comparison with the percentages of parthenocarpic fruit set after spraying with gibberellin A_3 (*6*) or with the auxin *p*-chlorophenoxyacetic acid (*7*), the percentages set after spraying with SD 8339 were low. This suggests either that SD 8339 is not readily absorbed by fig leaves or that it may not be easily translocated.

Maturity of the induced parthenocarpic fruits, as judged by color, taste, and texture, occurred about a week earlier than that of pollinated fruits. As shown in Fig. 2, the two types of fruit appeared to be identical externally. Internally, however, there were striking differences in color, extent of pedicel development, size of the fruitlets, and lignification of the endocarp tissue of the drupelets. The pulp in pollinated fruits was strawberry red, while that in parthenocarpic ones was amber. The pedicels and drupelets were larger in pollinated than in parthenocarpic fruits. In contrast to the pollinated fruits that contained numerous drupelets with lignified endocarp tissue which imparted a "seedy" texture when eaten, no lignification whatsoever of this tissue occurred in parthenocarpic fruits. The flavor of the two types of fruit, however, was similar.

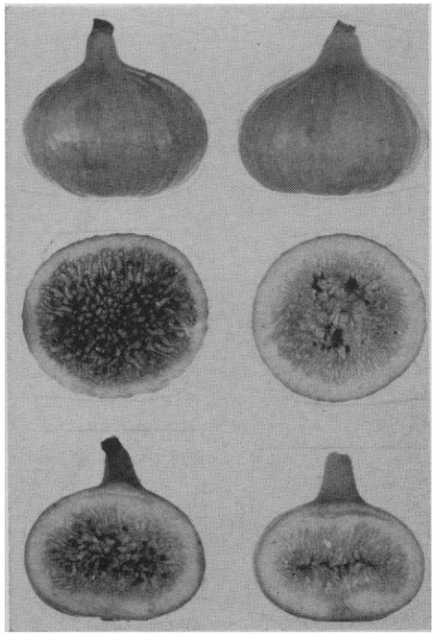

Fig. 2. Calimyrna figs resulting from cross-pollination (left) compared with those produced parthenocarpically by injection on 25 June of a 500-ppm solution of a kinin (right). Photographed on 20 August at fruit maturity.

Abscission of the youngest leaf on shoots that were sprayed with either concentration of SD 8339 was the only vegetative response noted as a result of the treatment.

The positive correlations between seed number and ultimate fruit size and between seed distribution and fruit shape have led to the widespread belief that hormones emanating from the seeds are direct stimulators of adjacent fruit tissues. It is significant, however, that the parthenocarpic figs produced with the kinin SD 8339 were identical, in all gross morphological characteristics, to those that have been produced with the auxin *p*-chlorophenoxyacetic acid (*7*) or with gibberellin A_3 (*6*). These results show indirectly that any of the three types of endogenous hormones needed for growth of the fig fruit can be supplied from some part of the plant other than the seeds. Furthermore, Coombe (*8*) has reported that the growth-retardant chemicals 2-chloroethyltrimethylammonium chloride (CCC) and tributyl-2, 4-dichlorobenzylphosphonium chloride (Phosfon-D), when applied to grape clusters before anthesis, increased the set of berries of both parthenocarpic and nonparthenocarpic cultivars. Thus it seems that we have to look for some explanation for fruit setting and growth beyond just the action of the three types of hormones, either individually or in concert. What appears to be the most plausible explanation is that these regulators trigger mobilization into the fruits of metabolites that are produced in other parts of the plant.

The process of fertilization creates a stimulus that apparently establishes a high metabolic gradient between the ovules and ovary on the one hand and vegetative organs on the other, which diverts the flow of food materials from the vegetative organs, sometimes even at the expense of their growth. For many years the only catalytic agent known to initiate these events was auxin. We know now, however, that gibberellin is even more active than auxin in this respect in some species, and a kinin has been shown here to be effective in the fig. Thus, it is possible that the sole function of the fertilized ovule or seed in relation to growth of the fruit is to synthesize one or more hormones which initiate and maintain a metabolic gradient along which foods and hormones can be transported from other parts of the plant. In the absence of fertilization and seed development, this gradient may be established by the application of exogenous auxins, gibberellins, and kinins.

Table 1. Parthenocarpic fruit (percentages) set after spraying or injecting Calimyrna fig syconia with the kinin SD 8339 on 25 June 1964.

Concentration of SD 8339 (ppm)	Percent fruit set on: 16 July	7 Aug.	20 Aug.
	Sprayed		
100	82	18	18
500	100	100	57
	Injected		
100	100	100	100
500	100	100	100
	Control (unpollinated)		
	0	0	0

JULIAN C. CRANE
Department of Pomology, University of California, Davis 95616

J. VAN OVERBEEK
Agricultural Research Division, Shell Development Company, Modesto, California

References and Notes

1. P. L. Goldacre and W. Bottomley, *Nature* **184**, 555 (1959); S. Lavee, *Science* **142**, 583 (1963).
2. D. S. Letham, *New Zealand J. Botany* **1**, 336 (1963).
3. R. J. Weaver and J. van Overbeek, *Calif. Agr.* **17**, 12 (1963).
4. Produced in laboratories of Shell Development Company.
5. J. C. Crane. *Ann. Rev. Plant Physiol.* **15**, 303 (1964).
6. ——— and R. C. Campbell, *Advances in Horticultural Science and Their Applications* (Pergamon, New York, 1962), vol. 2, pp. 204–209.
7. J. C. Crane and R. Blondeau. *Plant Physiol.* **26**, 136 (1951).
8. B. G. Coombe. *Nature*, in press.

27 January 1965