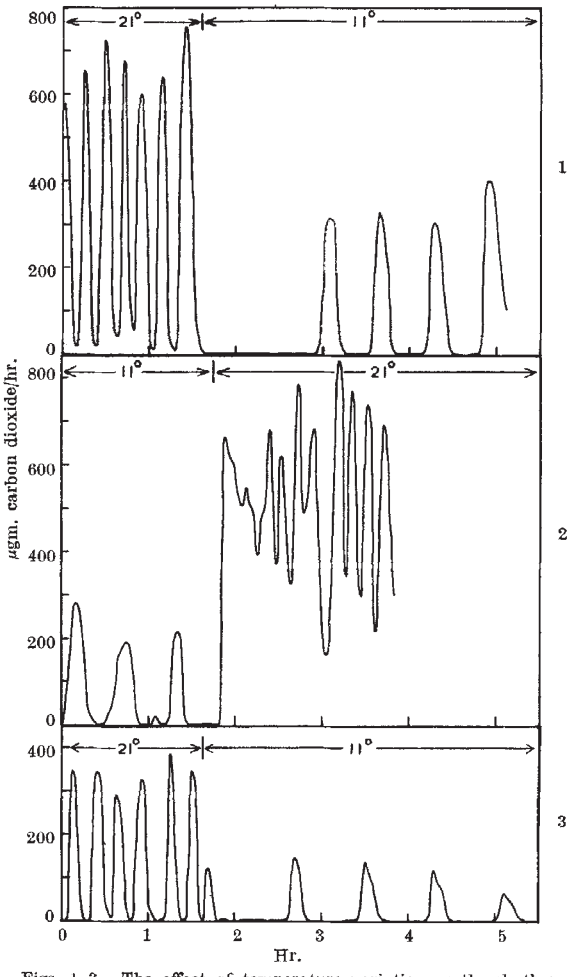
determined. The insects were kept in 12 : 12 hr. alternations of light and darkness and, at the commencement of an experiment, were transferred to a small flask which was placed in darkness and at a constant temperature at the end of a light period. The records presented here were derived from one insect, but five other cockroaches gave closely similar results.

In a stream of air initially free from carbon dioxide (relative humidity 80–90 per cent), darkness and at 21 ± 0·1° C. the period of the rhythm was 14·1 ± 0·8 min. (Fig. 1). On lowering the temperature to 11 ± 0·1° C. carbon dioxide output ceased for 76 min. and then the rhythm recommenced with a period of 35·8 ± 1·4 min. and with an amplitude approximately half that exhibited at 21° C. In an initially carbon dioxide-free air stream the period shows a $Q_{10} = 2·5$. The reverse procedure, increasing the temperature from 11° C. to 21° C., reduced the period from 35·8 ± 1·4 min. to 12·6 ± 1·9 min. (Fig. 2). A lag of 30 min. occurred between the change in temperature and the resumption of the rhythm, and the peaks during the first hour at the higher temperature were somewhat irregular. This may account for the slightly shorter period and larger standard error.



Figs. 1–3. The effect of temperature variation on the rhythm of carbon dioxide output of an adult cockroach maintained in darkness and in either a carbon dioxide-free (1 and 2) or normal (3) air stream. For explanation, see text

In a stream of normal air, darkness and at 21° C. the period of the rhythm was 16·2 ± 2·0 min. (Fig. 3). On reducing the temperature to 11° C. carbon dioxide emission ceased for 45 min. and afterwards recommenced with a period of 47·3 ± 0·03 min. In normal air the period shows a $Q_{10} = 2·9$ and again the amplitude was halved by the temperature reduction.

Removal of carbon dioxide from the air stream has no significant effect upon the period of the rhythm at 21° C., but at 11° C. the period is significantly longer in a normal air stream than in a carbon dioxide-free air stream. The rhythm was not inhibited or the period modified when insects maintained in an initially carbon dioxide-free air stream were illuminated with white light at an intensity of 3,000 lux.

These results contrast with those of Punt[3], who showed that *P. americana* lacks a rhythm of carbon dioxide emission, output being irregularly continuous in darkness, at 15° C. On the other hand, a rhythm of carbon dioxide output has been reported in the locust[4] in which the period was 2·5 min. in darkness, at 32° C. and in an initially carbon dioxide-free air stream. The locust exhibited the rhythm for only 24 hr. after shedding the last hopper skin. In contrast, the rhythm persisted for at least 4 days in the adult cockroaches used in this work. The period of the rhythm of emission of carbon dioxide in silk-worm pupæ has been shown to vary between 45 and 120 min. at 25° C.[5,6].

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'Watery Stipe' of Cultivated Mushrooms

In a recent paper, Lindberg[1] described a transmissible disease of *Helminthosporium victoriae* in which the infective agent, not identified, caused a stunting of the mycelium. This condition could be transmitted to healthy cultures through contact, either by growing the two types together or by treating normal cultures with a suspension of macerated diseased mycelium in sterile water.

A very similar condition has now been found in the cultivated mushroom, associated with a disorder known to growers as 'watery stipe', 'brown disease' or 'La France disease'. The macroscopic symptoms are variable and include the death of immature sporophores which may turn brown. Different degrees of water-logging of the tissues, particularly of the stipe, also occur. In mild cases this appears as translucent streaks on the stipes, but in extreme cases the whole sporophore may be saturated and exude drops of liquid from the surface of the pileus. Sporophore distortions, such as elongated and bent stipes, are commonly found. Cropping is much below normal and ceases prematurely, this being the most serious aspect of the disorder to the commercial grower. The variable symptoms have made positive macroscopic identification impossible. The only consistent

feature which has been discovered has been the degeneration of the mycelium, which is not always apparent from a cursory examination. If, however, fragments of the mycelium are plated out on an agar medium they will, if infected, produce weak, buff-coloured adpressed colonies without rhizomorphs. Healthy mycelium produces fluffy, white, more rapidly growing colonies with rhizomorphs radiating from the point of inoculation. The cells of the abnormal mycelium are shorter than normal and have a slightly swollen appearance. No other differences have been noted.

This mycelial degeneration has been transmitted to healthy cultures using methods similar to Lindberg's. With the double inoculation method, diseased and healthy cultures grow until their mycelia ultimately come into contact, but anastomoses between the hyphæ of the two colonies have not been seen. The coalescence of the two cultures is slow, as if there were antagonism between them, which is in marked contrast to the behaviour of two healthy colonies, where many of the rhizomorphs fuse. The growth of the healthy culture is usually weaker after coming into contact with the abnormal one; but there is no visible change in the appearance of the older mycelium. However, if this (originally healthy) mycelium is subcultured, its growth is abnormal.

Experiments with macerated mycelium have so far been confined to the use of suspensions containing fairly large fragments of mycelium which are capable of regeneration. Normal mycelium dipped in such a suspension grows at less than half the speed of mycelium dipped in suspensions of healthy mycelium or sterile water. Filtration to remove these mycelial fragments also removes the infective agent.

This investigation into the cause of the stunting of mushroom mycelium continues. Tests for the presence of bacteria have given negative results so far. The presence of a virus may be a possibility, although none has been found in fungi.

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GENETICS

Self-Incompatibility System in Two Mexican Species of *Solanum*

So far the genetics of self-incompatibility has been described in only one species of *Solanum*, namely, *S. chacoense*[1]. It is an extremely variable species which occurs in north and central Argentine, Paraguay, Uruguay and south Brazil and now includes *S. caldasii*, *S. subtilius* and *S. jujuyense*[2]. *S. chacoense* has a one-gene, multi-allelic, gametophytic system of self-incompatibility similar to that which has been found in three other genera of the Solanaceae, *Nicotiana*, *Petunia* and *Lycopersicon*. Recently I have found that *S. megistacrolobum* has the same system as its sister South American species *S. chacoense* (in the press), whereas the two Mexican species, *S. ehrenbergii* and *S. pinnatisectum*, have a two-gene system.

Progenies of 20 plants were grown from reciprocal crosses between unrelated clones of each species. Siblings within each family were crossed in all directions and each sibling was also crossed reciprocally with its parents. In *S. ehrenbergii* one family produced four intra-sterile groups of plants, but the family from the reciprocal cross produced six such groups. In *S. pinnatisectum* both the families from the reciprocal crosses gave six intra-sterile groups each. Different groups in one family were cross-compatible with some and cross-incompatible with other groups. There were reciprocal differences in the results of crosses between different groups.

The results obtained in the two Mexican species are conspicuous for being quite different from those usually obtained in the *Nicotiana* type system. They are explained on the basis of the following assumption. The genetics of incompatibility is controlled by two independently segregating loci each with a series of multiple alleles. Pollen determination is gametophytic and there may be individual action or epistasis between the alleles of the two series. In the style there is individual action of *S* alleles. A pollen grain is incompatible on a style when either one or both of its two alleles (of two different series) are also present in that style. This system may prove to be of general occurrence in the Mexican species and limited to them. It has been found to occur also in *Physalis ixocarpa*[3], a native of Mexico and Central America. In contrast, the 1-locus system appears likely to be confined to the species of South America.

The occurrence of the 1- and 2-locus gametophytic systems of incompatibility in the same genus *Solanum* is of considerable evolutionary interest. There is enough evidence to suggest that the 1-locus *Nicotiana* type of gametophytic incompatibility, occurring in a large number of flowering plants, was the first system of incompatibility to develop, and evolved early in the evolution of angiosperms[4]. The sporophytic system[4] and the 2-locus gametophytic system[5] were both derived from this system. It also seems justifiable to assume that the 2-locus system was able to evolve in the Mexican diploid tuberous *Solanums* because of their geographical isolation as a result of the separation of North and South Americas.

Some of the biological forces which might have led to this genetic distinction between the species of the two groups can be suggested. Several investigators[6], on the basis of cytological studies, have concluded that the basic chromosome number in the family Solanaceae is 6 and not 12, which occurs in most of its species. If it is assumed that the present basic number 12 for a large part of this family has been derived by doubling of the original basic number six, very early in the evolution of this family, then the two *S* loci in the Mexican species are the result of the duplication of the original *S* gene. However, the possibility of a segmental interchange bringing about duplicate *S* loci cannot be ruled out.

Whatever might have been the origin of two *S* loci, in the beginning they must have caused self-compatibility due to the competition interaction between the *S* alleles in the pollen[7]. The restoration of self-incompatibility could then have occurred by different methods in the two groups of geographically isolated Solanaceous species. (1) In the South American species having a 1-locus system of incompatibility, the restoration of incompatibility occurred by a selection for the loss of function of one of the two *S* loci—a phenomenon which seems to have occurred in some of the known tetraploid species (for example, *Trifolium repens*[8]) of other families. (2) In the Mexican species having two *S* loci, the restoration of incompatibility