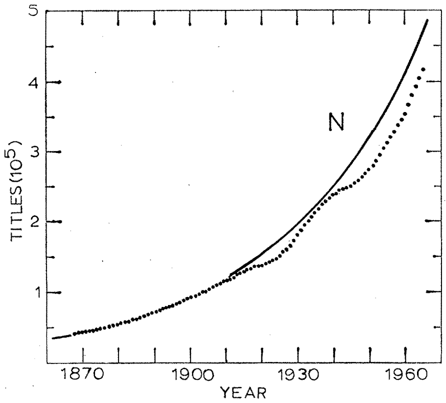

Fig. 2. The cumulative total of titles abstracted plus 41,000 titles estimated to be the cumulative total through 1867. The smooth curve N is given by Eq. 2 in the text.

for physics, biology, and mathematics respectively (*2*, fig. 2, p. 10). It appears likely that if Price and others took into account the literature prior to their statistical series, they would obtain substantially lower growth rates. This analysis supports the conjecture that the overall total scientific literature has been accumulating at a rate of about 2.5 percent per year, doubling about four times a century. When the literature prior to any year is ignored, the rate of growth is overestimated, and we may expect the future observation of spurious declines in growth, if growth rates actually remain constant, or failure to observe accelerations if they actually occur.

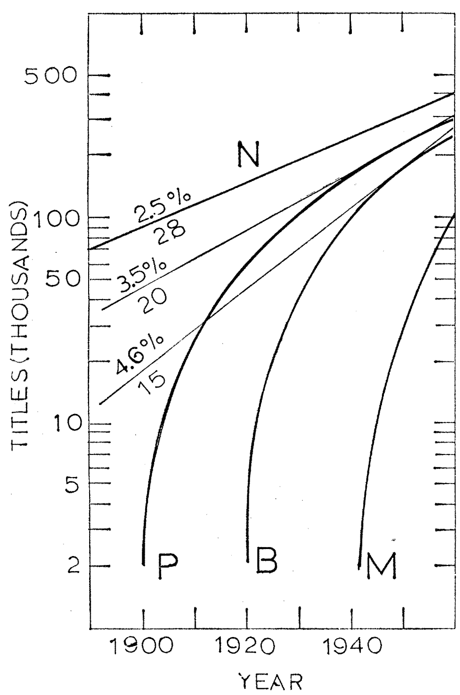

Fig. 3. Graphs on semilogarithmic paper of the theoretical curve N of Fig. 2 and of $P = N - 90{,}000$, $B = N - 150{,}000$, and $M = N - 250{,}000$ obtained by ignoring the literature prior to 1900, 1920, and 1940, respectively. The tangent lines show estimated growth rates increasing from 2.5 to 4.6 percent and doubling periods decreasing from 28 to 15 years. Note that relatively small changes in inclination of a straight line produce significant changes in estimated growth rates and doubling periods.

KENNETH O. MAY
Department of Mathematics,
University of Toronto,
Toronto, Canada

References and Notes

1. D. J. de Solla Price, *Science Since Babylon* (Yale Univ. Press, New Haven, 1961), chap. 5.
2. ———, *Little Science, Big Science* (Columbia Univ. Press, New York, 1963), chap. 1.
3. L. N. Ridenour, *Bibliography in an Age of Science* (Univ. of Illinois Press, Urbana, 1951).
4. The only published study of which I know is H. S. White, "Forty years' fluctuations in mathematical research," *Science* **42**, 105 (1915). Since the author gives no numerical data and omits vertical scales on his graphs, this work can be no more than suggestive of interesting lines of inquiry.
5. In some volumes of the *Mathematical Reviews* the total was estimated by sampling. After 1958 abstracts are serially numbered. In 1870 the *Jahrbuch über die Fortschritte der Mathematik* commenced the publication of an annual volume abstracting the entire world literature in mathematics for a single preceding year beginning with 1868. The plan was followed with fair success, but the substantial delays were unsatisfactory, and in 1931 the *Zentralblatt für Mathematik und ihre Grenzgebiete* began to abstract the mathematical literature more rapidly. Dissatisfaction with the Nazi control of these journals led to the founding of the *Mathematical Reviews* in 1940. The *Jahrbuch* stopped publication in 1942, but the *Zentralblatt* continues. Counts in the *Zentralblatt* from 1930 to 1965 are not inconsistent with those obtained from the *Jahrbuch* and the *Mathematical Reviews*. I have not made use of the more recently founded Russian *Referativni Zhurnal* and French *Bulletin Signalétique*, nor of the older Dutch *Revue Semestrielle*, since there seemed little likelihood that they would add information. The tabulated counts and derived data may be obtained from the author.
6. The *Jahrbuch über die Fortschritte der Mathematik* also fell behind, but it tried to publish the literature for a given year together, except for five occasions when two or more years were combined in a single volume. After 1940, the count is no longer of titles published in a year but of titles abstracted. If the tedious task of sorting out titles by year of publication were done, the points after 1940 would be shifted slightly to the left and up. The break in 1960 would disappear.
7. One should not expect too much from extrapolation beyond the range in which a curve is fitted, but Eq. 1 gives $n = 6$ for the year 1665, and this is not unreasonable for the period of the founding of the first scientific journals.
8. The estimate was obtained by integrating Eq. 1 from minus infinity to 1867. This amounts to adding together the theoretical annual frequencies given by Eq. 1 for all years prior to 1868. Equation 2 is just the integral of Eq. 1 that is asymptotic to the t-axis as time recedes. Any other integral of n is given by $N + C$, where C is a constant, but only $C = 0$ yields a curve of exponential growth. Taking $C < 0$ corresponds to ignoring some of the previously accumulated literature.
9. This work was done while I was on leave from Carleton College as visiting research mathematician at the University of California at Berkeley. It was partially supported by a grant from the Society of Sigma Xi. Counts and calculations were done by Robert H. Holmes.

18 October 1966

Hormonal Termination of Diapause in the Alfalfa Weevil

Abstract. *Topical treatment of the alfalfa weevil,* Hypera postica (*Gyllenhal*), *with the synthetic juvenile gonadotropic hormone 10,11-epoxyfarnesenic acid methyl ester effectively terminated summer diapause.*

Diapause is a condition of physiologic arrest that allows many insects to survive extended periods of cold, heat, and drought. In insects that diapause as adults, there is accumulation of lipid, substantial decrease in respiration, characteristically reduced activity and feeding, and no reproduction (*1–3*). The endocrine-mediated regulation of adult diapause in *Leptinotarsa decemlineata* (Say) has been confirmed in several studies since extirpation of the corpora allata (source of the juvenile gonadotropic hormone) was found to reproduce all the behavioral and physiologic effects associated with normal diapause (*1, 2*). However, these investigations have also shown that, although the surgically induced diapause is completely reversed by implantation of corpora allata, normally diapausing beetles are unaffected by implantation of the glands.

Thus, normally diapausing beetles apparently have some humoral inhibition that represses development of and secretion by the host's own corpora allata as well as implanted glands. Such inhibition is apparently not operative in allatectomy-induced diapause. Therefore, if diapause results from some humoral inhibition of corpora-allata development and secretion, it should be possible to circumvent the effects of the inhibitor and break diapause if the corpus allatum hormone itself or a sufficiently active synthetic hormone is supplied exogenously. We tested this hypothesis by treating diapausing adult alfalfa weevils, *Hypera postica* (Gyllenhal), with the synthetic juvenile gonadotropic hormone *trans-trans*-10, 11-epoxyfarnesenic acid methyl ester (*4*).

Adult weevils, reared in a manner described (*5*), already 2 weeks in diapause that would have normally continued for 12 to 14 weeks longer, were treated topically on the venter of the abdomen with 0.1, 1.0, 10, 50, or 100 μg of 10,11-epoxyfarnesenic acid methyl ester in 0.5 μl acetone. Control groups were either treated with acetone or left untreated. Each group contained 12

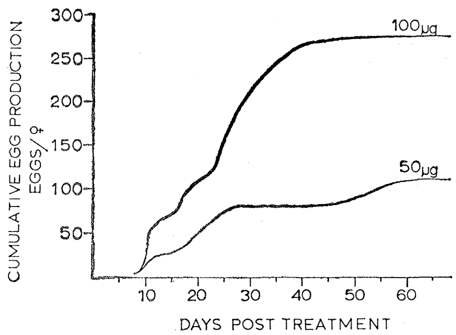

Fig. 1. Cumulative egg production of adult alfalfa weevils treated topically with 50 or 100 μg of *trans-trans*-10,11-epoxyfarnesenic acid methyl ester.

males and 12 females; all were held in 4-liter jars containing bouquets of cut stems of alfalfa.

In the groups receiving 50 or 100 μg of the epoxide, activity and feeding began within 3 days and increased from none to a very active "normal" rate within 6 to 7 days; oviposition began on the 8th day after treatment. Although there was some activity and slight feeding by the groups that had received the lower doses (0.1 to 10.0 μg), and a few mating pairs were observed in the 10-μg group, no oviposition occurred, and all returned to a diapause condition 2 to 3 weeks after treatment. Acetone-treated and untreated controls remained in diapause and demonstrated no feeding, mating, or oviposition during the 7-week period of observation.

Oviposition was the most readily measured phenomenon, being quantified over the 7-week period. Although the groups treated with 50 or 100 μg of epoxide produced significant numbers of eggs (Fig. 1), a definite dose-response relation existed: duration of oviposition and number of eggs produced were greater after the higher dosage. Additional experiments have demonstrated the reproducibility of these results.

Since an exogenous supply of synthetic hormone breaks diapause, it seems that one may justifiably conclude that diapause in the alfalfa weevil is essentially the result of an endocrine-deficiency syndrome of the corpora allata. However, the synthetic hormone seems not to simply overcome some kind of metabolic inertia and trigger or push the insect out of diapause; in that event the host's own corpora allata should take over, and the great disparity between groups of insects in response to oviposition would be eliminated. In view of the dose dependency of the ovipositional response, the corpora allata of these insects may have remained inactive. We believe that our results, taken together with the inability of de Wilde and de Boer (*1*) to break normal diapause in *Leptinotarsa* by implantation of corpora allata, argue in favor of the existence of an inhibition that suppresses corpora-allata activity and is therefore primarily responsible for the onset and maintenance of diapause.

The ability to terminate diapause with a synthetic hormone may have several practical uses: (i) continuous rearing in the laboratory of insects that normally diapause; (ii) immediate laboratory use of insects collected in a diapausing condition [the fact that parasites (*microctonus* sp.) have emerged from treated weevils indicates that development of the parasites was governed by the physiologic condition of the host; the parasites would normally have been recovered 3 to 4 months after the onset of diapause in the host]; (iii) potential control of insects, since termination or prevention of diapause in an insect exposes it to the consequences of a hostile environment which it normally avoids by entering diapause; thus the insect will be in a physiologic state to feed (in the possible absence of a host plant, as in winter) and to mate and reproduce during a period of environmental stress.

W. S. BOWERS
C. C. BLICKENSTAFF
Insect Physiology Laboratory and
Grain and Forage Insects Research Branch, U.S. Agricultural Research Service, Beltsville, Maryland 20705

References

1. J. de Wilde and J. A. de Boer, *J. Insect Physiol.* **6**, 152 (1961).
2. D. Stegwee, *ibid.* **10**, 97 (1964).
3. K. Slama, *ibid.*, p. 283.
4. W. S. Bowers, M. J. Thompson, E. C. Debel, *Life Sci.* **4**, 2323 (1965).
5. C. C. Blickenstaff, *Ann. Entomol. Soc. Amer.* **58**, 523 (1965).

31 October 1966

Background Selections of Geometrid and Noctuid Moths

Abstract. *Several common moths, collected at night and placed in an experimental box, showed daytime selections of backgrounds which tended to match the reflectance of their forewings. In one case, two distinct forms of a species showed different background selections.*

Many moths habitually rest upon natural backgrounds which match their wings (*1*). However, the extent to which moths can actively select appropriate backgrounds is uncertain. The only prior experimental study is that of Kettlewell (*2*), who demonstrated that light and dark forms of *Biston betularia* prefer white and black paper backgrounds, respectively. I now summarize evidence for reflectance matching in an experimental box by eight common geometrid and noctuid species collected during the summer of 1966 in Pelham, Massachusetts. In one of these species, the selections of a melanic form differed from those of the prevailing paler form.

The moths were trapped either at a 100-watt bulb or at trees baited with a mixture of brown sugar and beer. After collection, the moths were placed in an experimental box (38.1 cm square by 88.9 cm high) made of plywood 1.3 cm thick. The inner sides of the box were painted four shades of gray. A 1.9-cm^2 piece of stripping was glued into each corner of the box and painted on two sides with the two adjacent shades to make corner selections unambiguous. The top of the box was covered with a pane of frosted glass over a pane of clear window glass. The bottom was a sheet of aluminum foil. The box was placed in a wooded area where a thick canopy excluded direct sunlight.

Each morning, between 0600 and 0800 Eastern Standard Time, the background selections of the moths collected the previous evening were noted, and samples were taken for later identification and reflectance determination. Very few *Catocala spp.* were taken, as these moths were being color-marked and released in another study. All moths were identified with Forbes' keys (*3*).

The percent reflectance values for the sides of the box and the moths' forewings were obtained from a General Electric recording spectrophotometer equipped with a Davidson & Hemmengdinger tri-stimulus integrator. All measurements were made with daylight illumination and with pressed $BaSO_4$ as the white standard. For each moth species or form, the forewings of 12 moths (4 moths in the case of *Catocala spp.*) were glued as a montage onto black construction paper, and percent reflectance was measured over a