5. C. Yanofsky, *Proc. Natl. Acad. Sci. U.S.* 38, 215 (1952); ——— and D. M. Bonner, unpublished.
6. P. Lerner and C. Yanofsky, *J. Bacteriol.* 74, 494 (1957).
7. This investigation was supported by grants from the National Science Foundation and the U.S. Public Health Service.
8. E. Lennox, *Virology* 1, 190 (1955).

6 May 1958

Occurrence of Substances with Juvenile Hormone Activity in Adrenal Cortex of Vertebrates

No effects of vertebrate hormones upon insect growth have ever been demonstrated (*1*). During the past several years we have examined the effects of hundreds of growth factors including a series of vertebrate hormones (*2*), on the development of insects. Particular care was taken to inject the hormones at critical stages in the insect's life history when a hormonal effect on development would presumably be easiest to detect.

The most startling results were obtained with extracts of beef adrenal cortex (*3*). When such extracts were injected into pupae of the Polyphemus silkworm (*Antheraea polyphemus*), the pupae precociously molted into strange creatures which were intermediate between pupa and adult. These intermediates displayed large patches of pupal cuticle and retained such juvenile characters as pupal antennae and immature genitalia (Fig. 1). Indeed, they were indistinguishable from pupae that were injected with extracts of juvenile hormone prepared from insects (*4*) and from others into which active corpora allata were implanted. The experiments have been repeated several times with the same results. Aqueous extracts of the adrenal cortex mimic in detail the action of the juvenile hormone of insects. To our knowledge this is the first instance of a substance extracted from a vertebrate that has a specific morphogenetic effect on an insect, or indeed, on any invertebrate.

It is somewhat surprising that the first chemical extracted from a vertebrate to influence invertebrate growth should resemble the juvenile hormone, for this molecule appears to have no functional counterpart in the vertebrates. In insects it promotes larval development and prevents maturation. A similar agent is not known for vertebrates.

The active principle in the beef extracts has not yet been isolated, but we do know that it is not identical with any of more than 50 cortical components and their derivatives which we have tested so far. Nor can the effects of the cortical extract be duplicated by any of several hundred hormones, vitamins, metabolites, antimetabolites, and enzymes that have been tested (*1, 5*). In short, we are dealing with what appears to be a unique and specific group of substances with juvenile hormone activity, rather than nonspecific substances such as the numerous unrelated chemicals that activate crustacean chromatophores.

Since the cortical extract is rich in steroids, it is tempting to suggest that the active principle and the juvenile hormone itself are steroids. Such a conclusion is consistent with all that we presently know about the chemistry of the juvenile hormone (*4, 6*). In this connection it is noteworthy that Knowles, Carlisle, and Butler have reported that the ovarian-inhibiting hormone of prawns and bees may be a steroid and that they mention briefly that the effect of this hormone can be copied by administering the synthetic sex hormone, methyltestosterone (*7*). If the juvenile hormone and the ovarian-inhibiting hormone prove indeed to be steroids, then this important class of biologically active compounds assumes a central role in the humoral control of growth in invertebrates as well as vertebrates. Rather than being a recent innovation of the vertebrates, steroid hormones may prove to have a far more ancient lineage. Whether the active principle in the cortical extract is similar chemically to the juvenile hormone or merely acts in a similar way is being investigated. The possibility that the extract turns on the corpora allata of the injected pupae is also being studied.

LAWRENCE I. GILBERT
HOWARD A. SCHNEIDERMAN
Department of Zoology,
Cornell University, Ithaca, New York

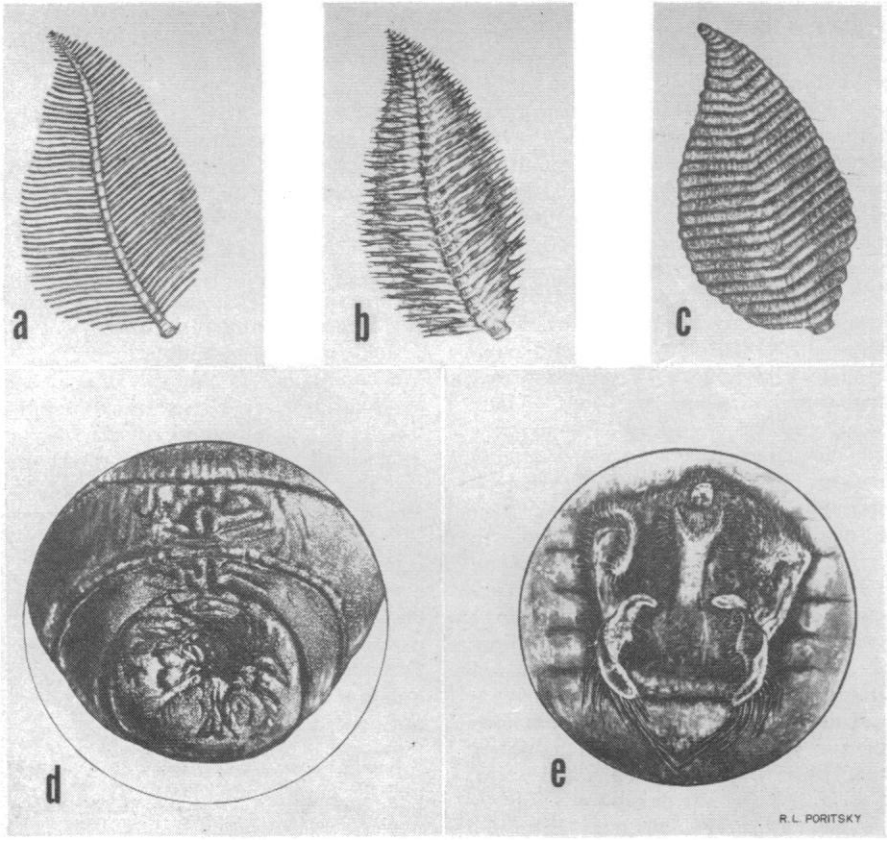

Fig. 1. (*A*) Antenna of an adult Polyphemus moth. (*B*) Antenna of an "intermediate" Polyphemus moth produced by injecting a pupa with adrenal cortical extract prior to initiation of adult development. (*C*) Antenna of a Polyphemus pupa. (*D*) Genitalia of an "intermediate" Polyphemus moth produced by injecting adrenal cortical extract into a pupa prior to initiation of adult development. (*E*) Genitalia of an adult Polyphemus moth.

References and Notes

1. C. M. Williams, *Harvey Lectures,* Series 47, 126 (1952).
2. This investigation was supported by a grant (H-1887) from the National Heart Institute, U.S. Public Health Service.
3. Aqueous extracts of beef adrenals were generously supplied us by Prof. S. L. Leonard of Cornell University and by Dr. P. Perlman and his associates at the Schering Corp., Bloomfield, N.J. The Schering Corporation also supplied us with many of the crystalline steroids that were tested.
4. C. M. Williams, *Nature* 178, 212 (1956).
5. M. Blaustein, thesis, Cornell University, 1957.
6. H. A. Schneiderman and L. I. Gilbert, *Anat. Record* 128, 618 (1957); C. M. Williams, H. A. Schneiderman, L. I. Gilbert, unpublished data.
7. F. G. W. Knowles and D. B. Carlisle, *Biol. Revs. Cambridge Phil. Soc.* 31, 396 (1956); D. B. Carlisle and C. G. Butler, *Nature* 177, 276 (1956).

24 April 1958