pendent variation therefore can not be due merely to a sensitivity adjustment of the D.C. amplifier too low to allow observation of a skin response occurring at small amplitude.

Independence of cortical rhythm and of the skin potential response to discreet stimuli is thus demonstrated. This would indicate that the mechanism controlling the sympathetic electrical skin response differs from that which controls or interrupts the alpha brain rhythm, although both may be simultaneously activated.

This study was made possible through a grant from the Rockefeller Foundation, and we are indebted to Drs. H. H. Jasper and M. Rheinberger for their aid.

T. W. FORBES
HOWARD L. ANDREWS

BRADLEY HOME
EAST PROVIDENCE, R. I.

PHYSIOLOGICAL EVIDENCE FOR THE SYNCYTIAL CHARACTER OF SMOOTH MUSCLE

COORDINATION between different parts of an organ can only be accomplished by some mechanism of conduction. Assuming that the single smooth muscle cells are units like striated muscle cells, peristaltic contractions and other coordinated movements of internal organs have usually been explained by making the ganglionic plexus, present in most viscera, responsible for coordination. However, the walls of the uterus, generally considered to be free of ganglion cells, are also capable of complicated, coordinated activity. This required the postulation of a peculiar type of conduction, which seemed to require investigation. The following observations give evidence that conduction in smooth muscle is due to its syncytial character. They also demonstrate conclusively that the excitatory processes of smooth muscle are not essentially different from those of striated muscle.

Although it is generally stated that direct electric stimulation of smooth muscle is difficult or impossible, thin strips of the longitudinal musculature of the uterus, under suitable conditions, respond to weak electric stimuli (less than 0.1 volt per cm). It is true, however, that the electric excitability of the uterus varies greatly during the sexual cycle and in a way similar to the sensitivity to drugs. The cat's uterus, for instance, is entirely inexcitable during anoestrus, but strong responses can be elicited in uterine strips prepared from animals which have previously received injections of theelin. The guinea pig's uterus is very excitable during oestrus and pregnancy, almost inexcitable during anoestrus.

The assumption that the response of the uterine strips is caused by the stimulation of nervous elements lying in the uterine wall is disproved by the fact that, in the non-pregnant uterus of the animals used, nerve stimulation only produces inhibition and by the observation that cocaine 1:200 does not abolish the response.

The possibility that some nervous plexus might be involved in the response of the uterine muscle can be eliminated by still another experiment. It has been found for nerve and striated muscle that an electric current is far less effective for stimulation if it passes at right angles than if it is oriented parallel to the fibers. In smooth muscle, on the other hand, the sensitivity would not depend appreciably on the orientation of the electric field applied, if the responses were initiated by the stimulation of a diffuse nerve plexus. It was found, however, that the threshold for electric stimuli was more than 20 times higher for a current passing at right angles than for a current passing longitudinally.

It is important that the response of uterine smooth muscle is propagated from the point of stimulation at a slow rate (0.2–5 cm per sec). Because nerve elements can not be involved in this response and because the individual smooth muscle cells are very short, it is necessary to assume that the excitation is propagated from muscle cell to muscle cell, as in heart muscle.

This conclusion is supported by some further observations. (a) The all or none relation between response and stimulus is valid. (b) The electric current has polar effects like those observed in nerve and striated muscle: On closing a current the response originates at the cathode, and anelectrotonus can be demonstrated. The different effects of the electric current on the cells near the cathode and anode can only be understood if the whole muscle is considered as one unit, comparable to a large cell. If the cells were units responding independently, all the cells between the electrodes should behave alike, since all are subjected to the same electric field.

Essentially the same results were obtained with some other smooth muscle preparations which contain ganglion cells (ureter and intestinal strips) confirming many of the old observations of Engelmann.[1]

The smooth muscles studied, consisting of innumerable small muscle cells, may be considered physiologically as giant smooth muscle cells in the same sense as the heart may be regarded as a giant striated muscle cell. This view not only explains many physiological phenomena in a simple manner, but also agrees with the findings of some histologists who have described broad anastomoses between the smooth muscle cells of visceral organs.

EMIL BOZLER

THE OHIO STATE UNIVERSITY

[1] T. W. Engelmann, *Arch. ges. Physiol.*, 3: 248, 1870.