Truman[8] proposed to divide animal clocks into 2 categories based on the difference in the mode of action of light. Type I clocks are stopped in continuous light and thus must have a 'dark process'. Type II clocks can free-run in continuous light. This ability of the latter is due to the fact that photoreceptors are external to the clock mechanism. In insects, the compound eyes or other 'organized' photoreceptors are not involved in type I clocks, associated with developmental rhythms such as of eclosion, hatching or brain hormone release, the photoperiodic receptors lying in the brain itself. In type II clocks, such as those controlling locomotor activity rhythm, the compound eyes are the principal and sometimes the only photoreceptors involved and the light information is transmitted synaptically to the clock. He suggested that photoperiodic clocks be classed as type I.

This suggestion has been supported by many studies[2], among which the study of Williams[9] in *Antheraea pernyi* and that of Steel and Lees[10] in *M. viciae* are especially excellent. They localized both the photoperiodic clock and the receptor to a small region of the protocerebral lobes of the brain.

Nevertheless, the results of our present experiments demonstrated an example of developmental photoperiodism in which compound eyes are the principal photoreceptors. The role of compound eyes as photoreceptors in insect developmental photoperiodism should be more carefully examined before it is generally denied.

1 We thank I. Shimizu and J. Nishiitsutsuji-Uwo for their helpful advice.

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Neural connections between antrum and duodenum

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Summary. Postprandial coordination of antroduodenal motility partly takes place via intrinsic mural pathways. The nature and origin of these nerve fibers have not yet been clarified. In this investigation using fluorochromic substances injected into the antrum and duodenum it was demonstrated that common central neurons for the antroduodenal area exist in the vagal nucleus.

The interdigestive motor activity of the stomach and the duodenum is cyclic with a quiescent phase (phase I), a phase of random activity (phase II), a phase of regular intense activity (phase III) and finally a transition phase between phases III and I (phase IV)[1-4]. Feeding interrupts the interdigestive cyclus immediately and induces rhythmic coordinated antegrade activity, the digestive phase. This fast response to feeding suggests a reflex phenomenon rather than a direct muscular reaction to food[5,6]. It seems to depend upon vagal integrity. Thus, when the vagal nerves are intact, the digestive pattern overrides the interdigestive pattern[7].

Reports have shown that nerve fibers run from the stomach to the duodenum[8,9]. From such studies one can hypothesize that coordinated antroduodenal motility takes place at least in part via intrinsic mural pathways. Such studies provide evidence for a hypothesis that coordination of motor accents in the distal stomach with those in the proximal duodenum is accomplished in part via intrinsic neural pathways. The nature and origin of these intramural nerve fibers are yet unexplained.

The use of nerve tracers has allowed better clarification of nervous pathways[10,11]. It was the aim of the present study to investigate the origin of antroduodenal nerves, employing this new technique.

Methods. In 8 rats (weight 150-250 g) the anterior aspect of the antrum and duodenum was exposed under pentobarbital anesthesia. Bisbenzimid 10% and True Blue 5% were injected randomly on the exposed sites. Both chemicals are transported in a retrograde fashion to the cell body of the nerve. Bisbenzimid provides a yellowish green fluorescence and True Blue a dark blue fluorescence. Bisbenzimid stains the nucleus and True Blue the cytoplasm and the nucleus. 2-3 days after injection the rats were anesthetized again and sacrificed by transcardial perfusion with 0.8% sucrose, 0.4% glucose and 0.8% sodium chloride, followed by formaldehyde 4%, tannic acid 1% and magnesium sulphate 4%. Specimens from antrum, duodenum and brain stem were examined.

Results. When the antrum was examined, neurons stained with a neuro-tracer injected into the duodenum could be observed in the antrum and vice versa (figs 1 and 2). No diffusion into the pyloric region was observed. When examining the vagal nucleus, it was noticed that staining was found almost exclusively in the left part of the vagal nucleus. Staining was particularly pronounced in the ventral aspect. In all animals, double stained neurons were found in the vagal nucleus (fig. 3) suggesting partly a common vagal innervation of the antrum and the proximal duodenum.

Discussion. This study provides morphological data supporting the existence of both local and central regulatory mechanisms. The findings clearly show individual central neurons innervating both antrum and duodenum in the rat. This central common control mechanism, which appears to be situated in the ventral aspects of the vagal nucleus,

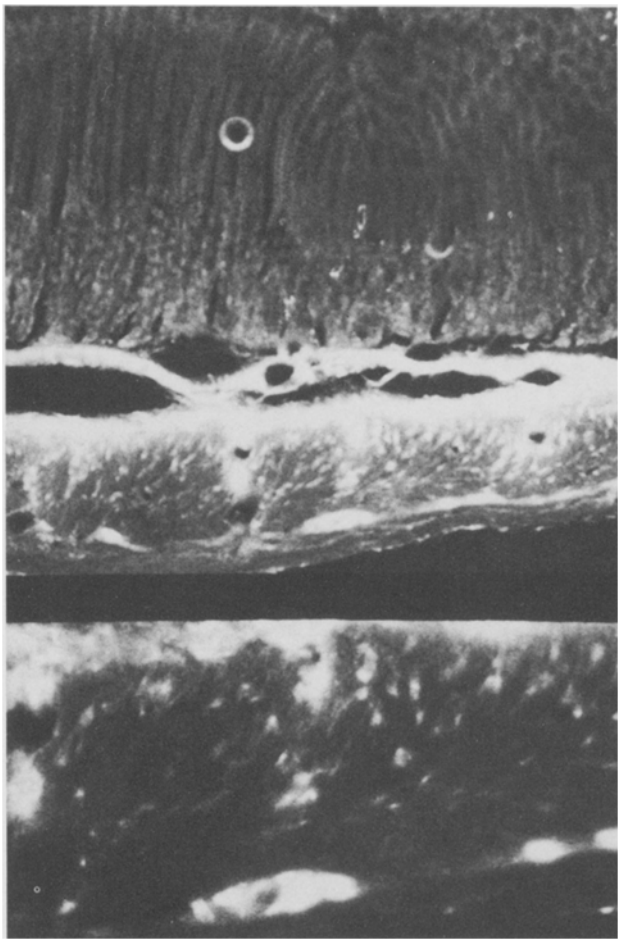

Figure 1. A cross section of antrum above, close-up below. Characteristically, clusters of nerve cells are seen. Bisbenzimid stained muscularis, True Blue stained cytoplasm.

Figure 2. A cross section of duodenum above, close-up below. Characteristically, single nerve cells are seen. Bisbenzimid stained muscularis and True Blue stained cytoplasm. No nucleus staining.

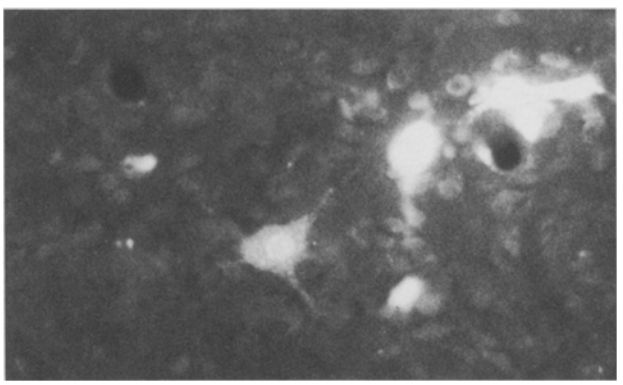

Figure 3. Double-stained neuron with bisbenzimid injected into the antrum and True Blue into the duodenum. The nucleus stained with bisbenzimid, the cytoplasm with True Blue.

might be responsible for the fast change of the interdigestive cyclus. Several pathways are possible. The study shows intramural passage of the fluorochromes from antrum to duodenum and vice versa. A local circuit initiating motor coordination is thus possible. Further studies are needed for full elucidation of the nervous pathways of the antrum and duodenum. Transsection excluding the intrinsic mechanism would be of great importance. Such studies are in progress.

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