cates the uncertainty in the density at high altitudes corresponding to the probable errors in the rocket data for altitudes below 200 km. The separation between the brackets at 275 km represents the additional uncertainty in the density when allowance is made for the quoted probable errors in the ballistic drag parameter and perigee altitude.

It is interesting to note that at 400 km the densities indicated by the present analysis are larger than those of the ARDC atmosphere (*6*) by a factor of approximately 40, and estimates of satellite lifetime are therefore reduced by the same factor for orbits with this perigee altitude. For example, a satellite with a mass of 10 kg and diameter of 50 cm, moving in an orbit with initial perigee and apogee altitudes of 400 km and 1000 km, respectively, has a lifetime of ~4 years in the ARDC atmosphere, versus 38 days in the present model (*b*).

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2. We follow the notation adopted in the announcements of the Harvard College Observatory, according to which a satellite will be identified by the year of launching, by a Greek letter indicating the order of launching, and by an Arabic numeral denoting visual brightness, the last added only when several objects appear during one launching. Thus the brightest object appearing in the first launching of 1957 is labelled 1957 α1, the next brightest, α2, and so forth.
3. We are indebted to Mr. H. E. LaGow and Drs. H. Friedman, H. E. Newell, J. A. O'Keefe, and F. C. Johnson for valuable discussions on the properties of the upper atmosphere. We are also grateful to Mr. W. F. Cahill of the National Bureau of Standards for the preparation of the machine program for integration of the equations of motion, and to Mr. J. H. Wegstein for his collaboration in writing the earlier forms of that program.
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6. Mass = 83.4 kg; diameter = 58 cm; total antenna length = 812 cm; mean antenna radius = 1.0 ± 0.3 cm (estimated). Extreme assumptions regarding the mechanism of reflection at the satellite surface lead to values for the drag coefficient, C_d, which vary from 2.0 to 2.7, hence we take $C_d = 2.3 \pm 0.3$. The ballistic drag parameter, Mass/$C_d \times$ Area, is then 89 ± 11 kg/m^2.
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23 January 1958

Localization of Stretch Reflexes by Recurrent Inhibition

Feedback discrimination between active cells, and hence between their functional fields, appears to be a general property of nervous systems. When a cell, or group of cells, is activated, neighboring cells are frequently inhibited, and contrast between active and inactive zones is thereby enhanced. Such interaction has been described in the eye of *Limulus* (*1*), the cat's cochlea (*2*) and retina (*3*), the cat's trapezoid body (*4*), and the afferent path to the cat's somatosensory cortex (*5*). It is the purpose of this report to show that the antidromic inhibition which results from spinal motoneuron activity (*6*) represents a similar discriminatory mechanism; it creates a negative feedback that is instrumental to the localization of stretch reflexes and thus aids in the control of fine movement.

Antidromic activation of motor nuclei inhibits monosynaptic reflexes of neighboring nuclei (*6*). During the period of inhibition a repetitive internuncial discharge occurs (*7*), but lack of anatomical evidence dissuaded Renshaw (*7*) from linking the two phenomena causally. As the time course of motoneuron aftercurrents is very similar to that of the inhibition, current between neighboring cells might be responsible for the inhibition (*8*).

Recent work in which microelectrodes were utilized has provided strong evidence that the inhibition is mediated through the interneurons described by Renshaw, as a result of their having been activated cholinergically by recurrent motor axon collaterals (*9*). To strengthen the chain of evidence, a comparison has been made between the actions of an anticholinergic drug on (i) the inhibition of neighboring motoneurons, (ii) the electrical signs of activity in Renshaw cells, and (iii) the antidromic electrotonus of motoneurons reflecting current between them, as recorded on ventral roots.

All preparations were immobilized by intravenous injections of Flaxedil. Figure 1 shows that an intravenous injection of 0.5 mg of dihydro-β-erythroidine (DHE) (*10*) per kilogram reduces in magnitude the inhibition exerted by an antidromic volley in one fraction of the first sacral ventral root upon a monosynaptic reflex elicted by stimulation of the corresponding dorsal root and recorded in the remainder of the ventral root. Coincidentally (Fig. 2*B*), DHE shortens the duration of Renshaw cell discharge, as has been previously described (*9*). The small change in ventral root electrotonus (Fig. 2*A*) does not exceed changes seen between controls recorded at various times during the experiment. It is evident that DHE differentiates between antidromic inhibition and Renshaw cell discharge, on the one hand, and ventral root electrotonus on the other.

Since the inhibitory system is acti-

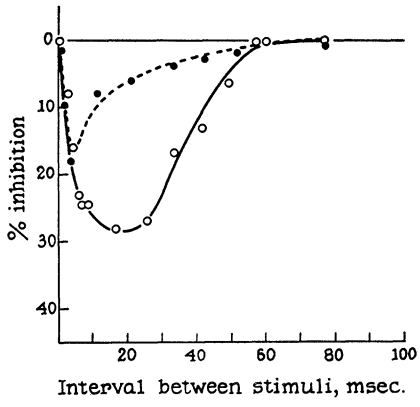

Fig. 1. Antidromic inhibitory curve obtained in a decerebrate preparation. For procedure, see text. Circles show inhibition before, dots after, intravenous injection of DHE. Each point was determined from 20 superimposed reflex responses.

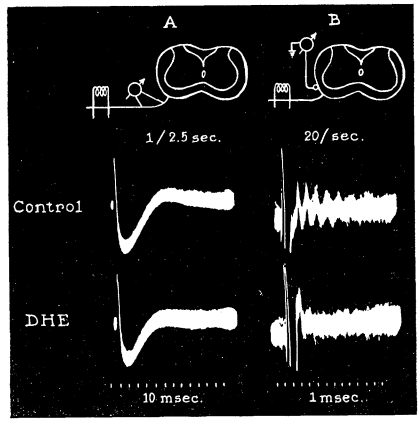

Fig. 2. Same experiment as illustrated in Fig. 1; (A) ventral root electrotonus, (B) Renshaw cell discharge, before and after injection of DHE. Diagrams show experimental arrangements.

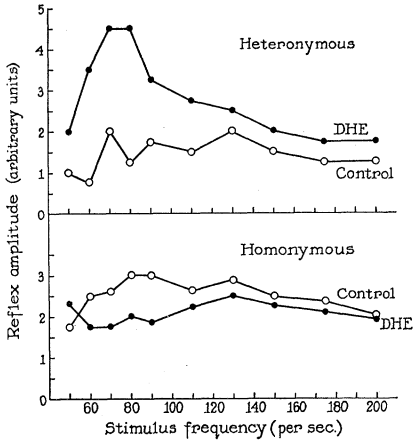

Fig. 3. Decerebrate preparation. For procedure see text. Graph shows, in arbitrary units, the effect of an intravenous injection of DHE on homonymous and heteronymous responses. Each point represents the average size of reflexes superimposed during a 1-second exposure.

vated by orthodromic as well as by antidromic impulses (*7, 11*), it may be well to abandon the term *antidromic* inhibition; *recurrent* inhibition is offered as a functionally more meaningful name. Because the system generally inhibits neighboring motoneurons, it has been assigned a nonspecific anticonvulsant function (*9*). In the normal animal, however, recurrent inhibition may play an important coordinating role. Monosynaptic reflexes, that represent stretch reflexes, ordinarily are confined to the path of afferent origin (homonymous reflexes). However, if the motoneurons of synergists are sufficiently excited, they may also be discharged (heteronymous reflexes). If the inhibitory system normally is a factor in restricting the field of stretch reflex action, then a reduction in the inhibition, as by the action of DHE, should result in an increase in heteronymous reflex transmission. To test this supposition, monosynaptic reflex discharges were elicited, before and after injection of DHE, by repetitive stimulation at frequencies of 50 to 200 per second. These frequencies were chosen because high-frequency stimulation is a convenient means for securing heteronymous reflex discharge (*12*) and because each response of the series will normally fall into the period of inhibition caused by its predecessor. Figure 3, taken from an experiment that is representative of many carried out with various flexor or extensor nuclei in spinal or decerebrate cats, shows a plot of the amplitudes of homonymous and heteronymous reflexes elicited in, and recorded from, the peripherally cut lateral and medial branches of the gastrocnemius nerves in a decerebrate cat. Administration of 1 mg of DHE per kilogram increased heteronymous, but not homonymous, reflexes. This discrimination requires no special distribution of Renshaw cells but, instead, follows from the fact that heteronymous reflexes usually are smaller than homonymous ones; an equal amount of inhibition exerted on both types would depress the smaller ones more. This discrimination varies from one experimental situation to another. In some experiments injection of DHE increased not only heteronymous reflexes but also homonymous ones. In several tests it was possible to evoke heteronymous reflexes after injection of DHE when they had been absent before.

It is concluded from the evidence described above that the recurrent inhibitory system tends to confine stretch reflexes to their paths of afferent origin.

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Occurrence of Unequal Amounts of Free Methionine in Male and Female Drosophila melanogaster

An investigation by means of two-dimensional paper chromatography (*1*) of the free amino acids occurring in *Drosophila melanogaster* has revealed that wild-type females contain twice the amount of free methionine found in males. In previous chromatographic studies of the free amino acids of *Drosophila* (*2–5*), only one qualitative difference in the sexes has been reported—the occurrence exclusively in males of an unidentified substance presumed to be a peptide (*3*). Quantitative differences among amino acids have been cited but not documented (*4*). In the study discussed in this report, the difference in methionine content was confirmed by microbiological assay. In addition, the identification of this substance was made, and proof of its homogeneity was established, by isolation and chromatographic study of a dinitrophenyl derivative.

In the original chromatographic studies, whole flies were extracted with ethanol and the extracts were evaporated to dryness and redissolved in saturated picric acid to yield a protein-free solution. Chromatograms were developed, phenol-ammonia-water being used in the first direction, and lutidine-water in the second direction. Prior to development, the spotted samples were treated with ammonium molybdate and hydrogen peroxide.

This procedure converts essentially all the methionine in the extract to methionine sulfone, in which form it migrates as a distinct spot well separated from valine and alanine. The presence of Ninhydrin-reactive material at this position, as a result of the oxidation procedure, associated with a corresponding decline in amount of material at the position normally occupied by methionine, greatly facilitated the identification of the latter substance. In five different wild-type stocks, visual examination of chromatograms indicated the occurrence of twice as much methionine sulfone (and therefore of methionine) in females as in males.

To make sure that the larger amount of material at the methionine sulfone position in chromatograms of extracts of females was attributable solely to the presence of a higher level of this substance, the material was isolated and identified. Two-dimensional chromatograms of extracts of females were prepared in the usual way but were heated without spraying with Ninhydrin. The amino acids could then be seen as fluorescent spots when viewed under ultraviolet light.

The material in the methionine sulfone position was cut out and eluted with water, and a dinitrophenyl derivative was prepared. Chromatography of the reaction product in four solvents revealed the existence of a single substance whose R_f corresponded in each case with that of authentic dinitrophenyl methionine sulfone. This showed that the isolated material was methionine sulfone, and that the larger amount of material observed at the methionine sulfone position in chromatograms of extracts of females must be due entirely to the presence of a larger amount of this substance. It should be clearly recognized that the material present in the original extracts of flies is free methionine.

A bacterial assay was made in an effort to secure independent evidence that levels of free methionine differ with sex. For this purpose, tungstic acid filtrates of frozen flies were prepared by adaptation of methods previously described (*6*). The extracts were assayed in accordance with standard microbiological procedures (*7*) in which *Leuconostoc mesenteroides* P-60 and a completely synthetic methionine-free medium (*8*) were used. The amounts of free methionine found in extracts of wild-type male and female flies are shown in Table 1. Two experiments were per-

Table 1. Free methionine content of protein-free extracts of *Drosophila melanogaster*.

Expt. No.	Batch	Male (μg/g*)	Female (μg/g*)
1	1	200	475
1	2	190	420
1	3	360	430
Av.		250	442
2	1	300	585
2	2	305	610
Av.		303	598

* Wet weight.