of bean seedlings as described earlier (*1*). After treatment of the bean seedlings, the remainder of the eluate was diluted with an additional 9 ml of water and tested for corn root curvatures as described above. If the active compound was found to occur on each of two adjacent strips of the chromatogram, its movement was calculated midway between the two strips. Indoleacetic acid was located on the chromatograms with the ferric chloride–perchloric acid reagent (*2*). The R_f values obtained (Table 1) indicate that the compounds causing root curvatures and bean malformations are identical and have R_f values substantially different from those obtained for IAA (*3*).

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References and Notes

1. R. W. Curtis, *Plant Physiol.* 33, 17 (1958).
2. T. A. Bennet-Clark *et al.*, *Nature* 169, 452 (1952).
3. This report is journal paper No. 1267 of the Purdue Agricultural Experiment Station. I am indebted to Mrs. Nancy Hung and Mrs. Hikmet Egilmez for technical assistance.

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Enzymatic Action of Rabbit Serum on Cortisone Acetate and Hydrocortisone Acetate

Enzymatic activity upon corticosteroids has been reported for tissues (*1*). The only known report, to date, on the enzymatic effect of serum per se is a paper by H. H. Wotiz *et al.* (*2*) on the metabolism of testosterone by human serum. We wish to report (*3*) the presence of an esterase in normal rabbit serum which is absent from normal human serum and which removes the acetate group from cortisone acetate and to a lesser degree from hydrocortisone acetate.

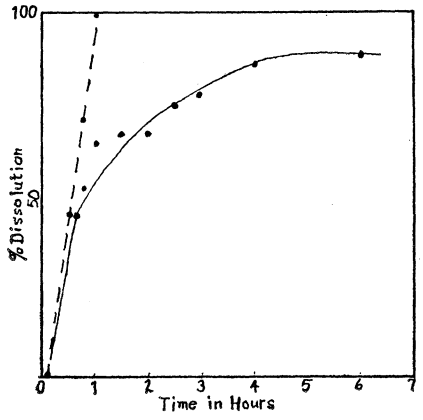

Fig. 1. Percentage dissolution of CA (dashed line) and HCA (solid line) in 10 percent normal rabbit serum in saline (NRS).

Following the initial studies in this laboratory on the effect of cortisone acetate upon the susceptibility of HeLa cells to poliovirus (*4*), the observation was made that in cultures maintained in Eagle's medium (*5*) with 10 percent human serum the cortisone acetate remained in particulate form, while in those cultures in which rabbit serum was substituted for the human serum the compound soon went into solution.

To investigate this phenomenon quantitatively, three sets of reaction tubes were initiated with 0.9 percent saline (SAL), 10 percent normal human serum in saline (NHS), or 10 percent normal rabbit serum in saline (NRS). To the tubes of each set were added either cortisone acetate (CA) (*6*), hydrocortisone acetate (HCA) (*6*), or hydrocortisone free alcohol (H-OH) (*6*), each resulting in a final concentration of 0.25 mg/ml. All tubes were incubated at 37°C. The hydrocortisone free alcohol was immediately soluble in all three reaction mixtures. The optical density of the tubes containing the steroid acetates was determined immediately and at intervals thereafter. Readings were made on the Bausch and Lomb Spectronic 20 with a wavelength setting of 560 mμ and were corrected with respect to homologous blanks. Figure 1 shows the percentage dissolution of the steroids with time.

Fresh rabbit serum was used in the experiments presented. Considerable activity could still be demonstrated, however, in serum stored at 4°C for 1 month. The heat lability of this enzyme is shown in the experiment summarized in Table 1. Fresh rabbit serum was heated at 56°C for 30 minutes. Comparable tubes were set up with NRS made with heated and unheated serum. Either HCA or CA was added at a final concentration of 0.25 mg/ml. Optical density values were followed with a Coleman, Jr. spectrophotometer with a wavelength setting of 560 mμ.

When a *p*H indicator such as phenol red was incorporated with the reaction mixture, it was seen that a *p*H drop from 7.4 to 6.8 occurred during the reaction period, indicating the formation of an acid. This did not occur in either the 0.9 percent saline or the 10 percent normal human saline reaction mixtures.

Samples of the NRS cortisone acetate reaction mixture were analyzed by the Merck Sharp & Dohme Research Laboratories. Their paper strip data showed that cortisone free alcohol was essentially the only form of cortisone present in the final reaction mixtures (*7*).

We conclude that normal rabbit serum contains an esterase capable of splitting CA into the free alcohol and acetic acid. Rabbit serum also has esterase activity toward hydrocortisone acetate. Human serum did not exhibit either esterase activity in the 24-hour test period.

Table 1. Optical density readings on Coleman, Jr. spectrophotometer. Normal rabbit serum unheated versus normal rabbit serum heated. All readings were corrected to a saline NRS blank of constant zero reading.

Time (hr)	CA, not heated	CA, heated	HCA, not heated	HCA, heated
0.00	0.32	0.31	0.20	0.20
0.25	0.28	0.31	0.18	0.20
0.50	0.22	0.31	0.17	0.20
0.75	0.12	0.31	0.097	0.20
1.00	0.00	0.31	0.097	0.20
2.00	0.00	0.31	0.097	0.20
3.00	0.00	0.31	0.097	0.20
24.0	0.00	0.31	0.097	0.20

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References and Notes

1. D. H. Nelson, L. T. Samuels, D. G. Willardson, F. H. Tyler, *J. Clin. Endocrinol.* 11, 1021 (1951); D. C. West and L. T. Samuels, *J. Biol. Chem.* 190, 827 (1951); M. L. Sweat, L. T. Samuels, R. Lumry, *ibid.* 185, 75 (1950); C. D. West, *Endocrinology* 49, 467 (1951); ———, F. H. Tyler, H. Brown, L. T. Samuels, *J. Clin. Endocrinol.* 11, 897 (1951); H. H. Wotiz and H. M. Lemon, *J. Biol. Chem.* 206, 525 (1954); B. Hurlock and P. Talalay, *Proc. Soc. Exptl. Biol. Med.* 93, 560 (1956); R. I. Dorfman, *Ann. Rev. Biochem.* 26, 523 (1957); D. H. Nelson, *Adrenal Cortex* (Josiah Macy, Jr. Foundation, New York, 1951), pp. 106–114.
2. H. H. Wotiz, R. R. van Baerle, H. M. Lemon, *J. Biol. Chem.* 213, 969 (1955).
3. This work was supported by the National Science Foundation.
4. M. M. Sigel and A. R. Beasley, *Proc. Soc. Exptl. Biol. Med.* 88, 86 (1955).
5. H. Eagle, *Science* 122, 501 (1955).
6. Manufactured by Merck Sharp and Dohme.
7. L. H. Sarett, Merck Sharp and Dohme, personal communication.

16 April 1958

Pericentral Cortical Projections to Motor and Sensory Nuclei

In an experimental neuroanatomical study in the cat (*1*) in which the Nauta-Gygax silver impregnation technique (*2*), was used, some of the corticobulbar fibers were found to be distributed (i) to the spinal trigeminal complex and the adjacent lateral tegmentum up to the level of the isthmus and (ii) to the region of the nuclei cuneatus and gracilis. No corticofugal fibers were distributed to the motor nuclei. Moreover, lesions within the limits of the cat's "motor cortex" (*3*) revealed that the projection to the spinal trigeminal complex and the adja-

cent lateral tegmentum originates primarily in the face area, while the projections to the region of the nuclei cuneatus and gracilis arise primarily in the arm and leg areas, respectively.

In four human cases (*4*) with extensive lesions of the hemisphere, a similar distribution was observed; here, however, degenerating fibers reached the motor nuclei, a projection almost completely lacking in the cat. These differences suggested that in the cat the corticofugal impulses reach the cranial motor nuclei "indirectly" through one or more synapses in the spinal trigeminal complex or the lateral tegmentum, or both. In man, this indirect pathway is paralleled by additional "direct" corticonuclear connections. The existence of "direct" and "indirect" corticonuclear connections is substantiated by electrophysiological findings of a similar nature in regard to the spinal cord, reported by Bernhard and Bohm (*5*).

In an attempt to gain more detailed information concerning the origin of these projections in man, lesions were placed in the precentral face area of the rhesus monkey and the chimpanzee (*6*). These lesions were found to produce degeneration of corticofugal fibers to the motor nuclei and the lateral part of the tegmentum adjacent to the trigeminal complex. The corticonuclear fibers were found to originate primarily in the posterior part of the precentral gyrus, while the projections to the lateral tegmentum exhibited a more diffuse precentral origin. However, in comparing the findings in these animals with those in our human material (*4*) it was interesting to note that in both the rhesus monkey and the chimpanzee, following precentral lesions, only a few degenerating fibers were distributed to the spinal trigeminal complex proper. In the human material, on the other hand, in which the lesions were rather extensive, such degenerating fibers to the trigeminal complex were much more abundant. These differences suggested that the fibers to the lateral tegmentum and the motor nuclei constitute a predominantly precentral projection, while those to the secondary sensory cell groups of the trigeminus constitute a primarily postcentral projection. This was substantiated by the findings in three additional experiments in the rhesus monkey, with lesions of the postcentral face area, in which the degenerating fibers were found to be distributed primarily to the trigeminal complex (*6*).

On the basis of these findings in the brainstem, the inference was made that in the spinal cord a similar arrangement might exist. In order to investigate this further, an extensive series of experiments was initiated in which in the rhesus monkey lesions were placed in the pre- and postcentral cortical regions. Although this extensive study has not yet been completed, the first group of experiments with lesions in the upper two-thirds of the pre- and postcentral gyri revealed an arrangement similar to that in the brainstem. The lesions in the precentral gyrus produced degeneration of corticofugal fibers which were primarily distributed to the intermediate region and the anterior horn of the spinal cord. Lesions in the postcentral gyrus, on the other hand, produced degeneration of corticofugal fibers distributed primarily to the posterior horn of the spinal cord. However, some overlap between the pre- and postcentral projections seems to exist, especially in the leg area.

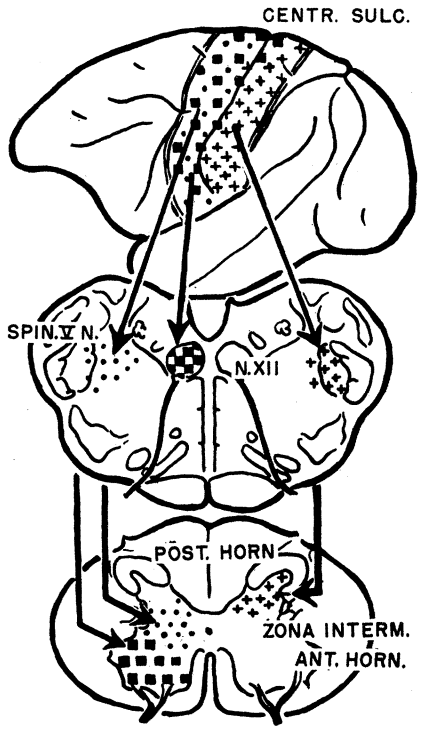

Fig. 1. Diagrammatic representation of the distribution pattern in the corticobulbar and corticospinal projections in the rhesus monkey.

The total of these findings suggest that in the corticobulbar and corticospinal projections (see Fig. 1), at least three main groups can be distinguished: (i) a primarily precentral projection to the internuncial elements (the lateral parts of the tegmentum of the lower brainstem and the external basal parts of the posterior horn and the zona intermedia of the spinal cord); (ii) a primarily precentral projection to the motor neurons (cranial motor nuclei, and spinal anterior horn cells), which seems to be characteristic of primates; (iii) a primarily postcentral projection distributed to secondary sensory cell groups (trigeminal complex and posterior horn of the spinal cord). The first two groups of projections from the precentral "motor" cortex in all likelihood are primarily involved in "motor" functions. The third group of projections, on the other hand, probably constitutes a "sensory" feedback mechanism capable of influencing secondary sensory cell groups, from which the postcentral gyrus ultimately receives at least part of its information. Such a cortical influence upon secondary sensory cell groups in the spinal cord was demonstrated physiologically in the cat by Hagbarth and Kerr (*7*).

Moreover, another cortical projection system was found to be distributed to the region of the nuclei cuneatus and gracilis (*1, 6*). However, in the rhesus monkey the origin of this system does not seem to be limited to the postcentral gyrus but in part arises from the precentral gyrus (*6*). This holds true especially for the projections from the precentral leg area to the region of the nucleus gracilis. This projection system probably represents another sensory feed back mechanism primarily involved in proprioceptive sensory modalities. In this respect it is interesting to note that the differential cortical origin of the projections to the nucleus proprius and the nuclei cuneatus and gracilis, respectively, seems to parallel the possible differences in cortical receiving areas for such sensory modalities (*8*).

Since the pyramidal tract contains the majority of the corticofugal fibers discussed above, the present findings are apt to throw new light upon this classic "motor"system. In fact, they suggest that within the pyramidal tract, at least, two subdivisions can be distinguished, one of which is, in all likelihood, primarily involved in "motor" functions, while the other is primarily involved in "sensory" functions; this concept has already been suggested by Peele (*9, 10*).

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References

1. H. Kuypers, *Anat. Record* 124, 322 (1956); *J. Anat.* 92, 193 (1958).
2. W. J. H. Nauta, and P. A. Gygax, *Stain Technol.* 29, 91 (1954).
3. H. W. Garol, *J. Neuropathol. Exptl. Neurol.* 1, 139 (1942).
4. H. Kuypers, *Brain*, in press.
5. C. G. Bernhard and E. Bohm, *A.M.A. Arch. Neurol. Psychiat.* 72, 473 (1954).
6. H. Kuypers, *J. Comp. Neurol.*, in press.
7. K. E. Hagbarth and D. I. B. Kerr, *J. Neurophysiol.* 17, 295 (1954).
8. W. R. Adey, R. Porter, I. D. Carter, *Brain* 77, 325 (1954); C. N. Woolsey, W. H. Marshall, P. Bard, *Bull. Johns Hopkins Hosp.* 70, 399 (1942).
9. T. L. Peele, *J. Comp. Neurol.* 77, 693 (1942).
10. These investigations were supported in part by research grant No. B-1131 from the division of Neurological Diseases and Blindness of the U.S. Public Health Service.

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