terial was visible, probably sodium fluoride. The temperature was then raised to 125°C, and after ½ hour the tube exploded with extreme violence. Nothing was recoverable.

Pentafluorotoluene. To the Grignard reagent prepared from 1.31 g (0.054 g-atoms) of magnesium turnings and 13.07 g (0.054*M*) of methyl iodide in 15 ml of anhydrous ether, was added 10 g (0.054*M*) of hexafluorobenzene. Slight refluxing of the ether was observed during the addition. The mixture was refluxed for 2 hours more, cooled in ice, and decomposed by the addition of 50 ml of cold 10 percent hydrochloric acid. The organic layer was separated, dried (Na_2SO_4), and the ether was removed. The residual liquid, 7.1 g, was analyzed by mass spectrometer and found to contain 65 percent unreacted hexafluorobenzene, 3 percent pentafluorotoluene, and 20 percent of a nonvolatile residue which has not been characterized (7).

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References and Notes

1. E. T. McBee, V. V. Lindgren, W. B. Ligett, *Ind. Eng. Chem.* 39, 378 (1947).
2. Y. Desirant, *Bull. classe. sci. Acad. roy. Belg.* **41**, 759 (1955).
3. J. A. Godsell, M. Stacey, J. C. Tatlow, *Nature* 178, 199 (1956).
4. M. Hellmann *et al.*, paper presented before the Industrial and Engineering Division, Fluorine Symposium, at the 130th meeting of the American Chemical Society, Atlantic City, N.J., Sept. 1956; *J. Am. Chem. Soc.*, in press.
5. W. J. Pummer and L. A. Wall, unpublished work.
6. G. M. Bennett, G. L. Brooks, S. Glasstone, *J. Chem. Soc.* 1935, 1821 (1935).
7. This article is based on work sponsored by the Bureau of Aeronautics, Department of the Navy, Washington, D.C.

14 November 1957

Homing in Nonmigratory Bats

Homing at high speeds (*1*) and over long distances (*2*) has been observed in species of bats which normally migrate and which may have some familiarity with the territory covered. Although the means by which a bat navigates in returning to its roost are not known, it is known that visual and auditory clues are important factors in the homing of birds (*3*). In order to test the importance of these factors in bat movements, experiments are being conducted with the big brown bats, *Eptesicus fuscus fuscus,* which seems to be nonmigratory in the Cincinnati, Ohio, area. Bats collected from roosts in Cincinnati were carried north or south and released in locations with which they were not familiar.

The 155 bats taken north were captured, weighed, and banded on 20 July 1957. These bats were divided into five groups according to the amount of wear on their teeth—the higher the number of the group, the older the bats in the group (*4*). This criterion indicates only the relative age and not years (*5*). However, the season's young, born during the last week in May and the first week in June, were distinguishable. Of the 155 bats, all of the 57 males and 47 of the 98 females were juveniles. Among the other females, 16 were from group 2, 21 were from group 3, 7 were from group 4, and 7 were from group 5. All of these females had borne young, and the mammary glands had regressed. On 21 July they were transported in the trunk of an automobile in cages surrounded with crushed ice, since the temperature was in the middle 90's. The bats seemed torpid.

The bats were reweighed and released in the late evening at Pilgrim, Mich., north of Frankfort, 450 miles north of their home roosts. The temperature was below 70°, and many of the bats had to be exercised individually before they would fly voluntarily.

The roosts were rechecked on 24 August. Three bats were recaptured, all adult females. Two of these—one from group 2 and one from group 5—had been banded for the first time on 20 July; the third, from group 4, had been recaptured from the same roost nine times in eight different calendar months over a period of 2 years. Two other bats were observed after release. One juvenile male was killed 3 days after release, two miles north of the point of release; another juvenile male was observed about a mile south on the day following release. On 26 Oct., four more females were recaptured after they had returned from Michigan, two from group 3 and one each from groups 4 and 5.

For the southern trip, only 18 bats (nine males and nine females) could be captured on 31 July in Cincinnati. Eight of the males and six of the females were juveniles; one male and one female were from group 2; one female was from group 3, and one was from group 4. These were released at Reelfoot Lake, Tenn., 340 miles to the southwest, on 2 Aug. 1957. The temperature was 95°F, and all the bats flew immediately upon release. On 17 Aug., two of these bats were recaptured at the original roost in Cincinnati. One was a female from group 4 which had previously been captured nine times in seven different calendar months, from April through December, over a period of 2 years. The other was a juvenile male about 2 months old. Another of the juvenile males released at Reelfoot Lake was killed in Charleston, Ill., on 10 Sept. This bat was already north of the latitude of Cincinnati and 200 miles to the west.

The big brown bats seem to be nonmigratory in the Cincinnati area, since individual banded specimens have been collected in ten different calendar months. Two of the bats that returned during these experiments had been recaptured nine times in the previous 2 years. The juvenile male about 2 months old was certainly not familiar with the territory covered. Both of the bats that returned from Tennessee gained weight on the trip, whereas five of the seven bats that returned from Michigan lost weight. Two of 18 (11 percent) bats returned from Tennessee; seven of 155 (4.6 percent) returned from Michigan. However, the difficulties encountered in collecting bats in large attics and barns make our recapture figures minimal, and no significance can be attached to the difference in percentage of bats returned.

In our experiments, bats returned 450 miles south within a month or less, and 340 miles northeast within 2 weeks or less, to their original roosts, over unfamiliar territory (*6*).

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References and Notes

1. H. C. Mueller and J. T. Emlen, Jr., *Science* 126, 307 (1957).
2. E. Smith and K. Hale, *J. Mammal.* 34, 122 (1953).
3. D. Griffin, in *Recent Advances in Avian Biology,* A. Wolfson, Ed. (Univ. of Illinois Press, Urban, 1955).
4. J. Christian, *Memorandum Report 53-16* (Naval Medical Research Institute, 1953).
5. J. Hall, R. Cloutier, D. Griffin, *J. Mammal.* 38, 407 (1957).
6. We appreciate the helpfulness of George McDuffie of the University of Cincinnati and of Dr. and Mrs. Robert McEwen of Oberlin College.

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6-Aminonicotinamide and Acute Degenerative Changes in the Central Nervous System

Two analogs of nicotinic acid and nicotinamide, 3-acetylpyridine (3-AP) and 6-aminonicotinamide (6-AN), cause toxic effects in mammals which are prevented by the administration of the metabolite and some of which resemble nicotinic acid deficiency (*1, 2*). Neurological changes appear to be a prominent feature of the intoxication. As examples, mice given 3-AP lose control of the hind legs and eventually become almost completely paralyzed (*1*); in nicotinic acid deficient dogs a toxic dose of 3-AP causes limb paralysis (*3*); and 6-AN in oral doses of 15 to 30 mg/kg produces in rats and rabbits loss of motor control and paralysis (*4, 5*). We undertook a toxicological study of 6-AN in preparation for its possible clinical use as an anticancer

agent (*6*). Its potential in this regard is based on reports of its inhibitory activity against several experimental tumors (*4, 7*). In an attempt to determine the nature of the paralytic effects, we observed characteristic lesions in the central nervous system in rats. Subsequent study revealed the presence of similar lesions in paralyzed cats and dogs.

A single intraperitoneal injection of 8 mg/kg was given to 47 male rats (the Nelson subline of Carworth Farms Wistar) which weighed between 212 and 303 g and which were maintained on a stock diet (*8*). Nineteen were killed under ether anesthesia at various times between 1 and 10 days; 18 others died between 1 and 11 days (the majority during the second and third days); the remaining 10 rats survived. Incoordination of the hind legs was evident in almost all rats within 24 hours after the injection. By the second day paralysis was present in the hindquarters and the more affected rats were unable to stand. At 3 days and later, all extremities were involved in the sicker individuals, and by 10 days the muscles of the hind legs were wasted. Five of the survivors were also paralyzed during the first week; but these eventually recovered and by the end of the third week after injection were outwardly normal.

Spinal cords and brains were obtained for pathological study at different times from animals which were judged to be the most disturbed: three at 1 day, two at 2 days, one at 4 days, and one at 10 days after injection. Marked destruction was found in anterior horn cells in the spinal cord and in nuclei within the brain stem. The lesions were detectable as early as 24 hours after the injection, when they consisted of petechial hemorrhages and early degenerative changes in neurons. These changes were maximal by 4 days, when they were characterized by advanced necrosis and disappearance of cell bodies (Fig. 1).

Three cats were injected intravenously with 30, 15, and 7.5 mg/kg of 6-AN. Dysmetria was noted within 5 hours in the hindquarters of the animal given the highest dose. The disturbance advanced and at 72 hours all four limbs were paralyzed. The knee-jerk and the placing reflex were still active in the hind legs, and ipsilateral flexion could be elicited by pinching the toe-pads. By 10 days the hind leg muscles were wasted. The animal was killed with pentobarbital sodium, and the central nervous system was removed for microscopic study. Lesions were found in the spinal cord and brain stem similar to those seen in paralyzed rats (Fig. 1). The two surviving cats also developed severe postural disturbances which were maximal at 72 hours after injection. Thereafter the pair recovered steadily; but 4 months later the animal that had been given the higher dose still showed dysmetria in its hind legs.

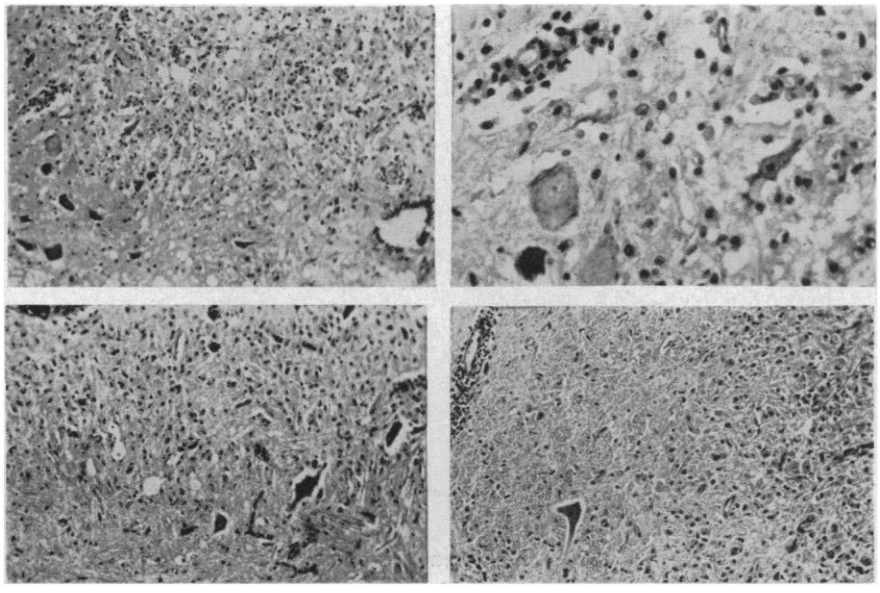

Fig. 1. Sections of spinal cord or brain stem stained with hematoxylin and eosin. (Top left) Rat spinal cord 4 days after a single intraperitoneal dose of 8 mg/kg of 6-AN. A major portion of the anterior horn is destroyed. At lower left a few neurons persist. (Top right) Higher power from area at left of the photograph in top left. At right, area of severe damage with shrunken neuron containing pyknotic nucleus. At upper left, cellular infiltration around capillary. (Bottom left) Cat spinal cord 9 days after single intravenous dose of 30 mg/kg of 6-AN. Severely damaged anterior horn. A few intact but damaged neurons at periphery. (Bottom right) Same animal as that shown at bottom left. Severe damage to brain stem nucleus, especially at right. Perivascular cuffing at left.

Five dogs, given repeated daily doses of 4 mg/kg per day either intravenously or by mouth, showed varied responses. One tolerated ten doses without evident disturbance. Another, after seven doses, was hyperexcited, hyperthermic, and uncoordinated and showed continuous twitching of the ears and cheeks. Unfortunately it died unobserved during the eighth day. A third animal received ten doses during 11 days of treatment and died at 18 days. During the last week a variety of neurological disturbances developed: continuous bobbing of the head except during or immediately after purposeful movements, twitching of the ears and lips, and incoordination of hind legs. The last two dogs became paralyzed in all four extremities after 1 week of treatment. At this time patellar and flexion reflexes were active, and there were no signs of central excitation. The animals swallowed with difficulty and salivated excessively. They were killed at 8 and 10 days by means of intravenous administration of pentobarbital sodium. As in the two previous species, lesions were found in the anterior horn of the spinal cord and in brain stem nuclei (*9, 10*).

Such neuropathological damage is unusual in its severity and in its selective localization in the gray matter of the anterior horn and of the brain stem. Possibly its occurrence is related to the capacity of central nervous tissue to synthesize in vitro the 6-AN analog of diphosphopyridine nucleotide through exchange reactions (*12*). The formation of the 3-AP analog of diphosphopyridine nucleotide has also been shown to occur in brain tissue, and it has been suggested that this reaction is responsible for the toxic effect of 3-AP (*13*). However, lesions similar to those produced by 6-AN have not been observed in animals given 3-AP (*14*).

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References and Notes

1. D. W. Woolley, *J. Biol. Chem.* 157, 455 (1945).
2. W. J. Johnson and J. D. McColl, *Science* 122, 834 (1955).
3. E. G. McDaniel, J. M. Hundley, W. H. Sebrell, *J. Nutrition* 55, 623 (1955).
4. S. L. Halliday *et al.*, *Federation Proc.* 16, 190 (1957).
5. W. J. Johnson, *Can. J. Biochem. and Physiol.* 33, 107 (1955).
6. This work was supported in part by a grant (CY-3192) from the National Cancer Institute, National Institutes of Health, U.S. Public Health Service. We are indebted for assistance to Miss Alice Cronin and Mr. Pedro Vidal. The sample of 6-AN was kindly supplied by Dr. Karl Pfister and Mr. John Weijlard of Merck and Co., Rahway, N.J.
7. D. M. Shapiro, L. S. Dietrich, M. E. Shils, *Cancer Research* 17, 600 (1957).

8. All animals received water and food *ad libitum*. Rats were fed with a commercial stock diet (Purina Laboratory Chow); cats, with ground horsemeat or beef replaced once weekly with ground beef, pork, or sheep liver and once weekly with fish; and dogs with three parts Purina Dog Kibble to one part of ground meat, replaced once weekly with one part of liver.
9. Drs. Abner Wolf and David Cowen concurred in the pathological findings of these preliminary studies.
10. This report has dealt only with the findings related to the central nervous system. A description of the course of intoxication, the hematological changes, and the visceral lesions is in preparation. After this study was completed, our attention was drawn to a description of the pathological effects of 6-AN in young rats and mice (*11*).
11. M. Morsiani and E. Soffritti, *Riv. anat. patol. e oncol.* 11, LXXI (1956); A. Baserga, M. Morsiani, G. M. Mariuzzi, *Acta vitaminol.* 10, 195 (1956).
12. W. J. Johnson and J. D. McColl, *Federation Proc.* 15, 284 (1956).
13. N. O. Kaplan *et al.*, *Science* 120, 437 (1954).
14. S. P. Hicks, *Am. J. Pathol.* 31, 189 (1955).

18 November 1957

Influence of Gibberellin on Xanthium Flowering as Related to Number of Photoinductive Cycles

In 1956 Lang (*1*) reported that biennial *Hyoscyamus niger*, when treated with gibberellin, bolted and bloomed the first season without cold or long-day treatments and that the long-day, annual form of this species bloomed under short days when treated with gibberellin. As early as 1928 Kurosawa (*2*) had noted that rice plants infected with *Gibberella fujikuroi*, the fungus which produces gibberellin, flowered earlier than uninfected plants. In 1951 Mitchell, Skaggs and Anderson (*3*) reported that bean plants, when treated with gibberellin, bloomed earlier than the controls. Lang, however, was the first to demonstrate that gibberellin could substitute for long-day and low-temperature treatments in the induction of bolting and initiation of flowering.

Soon after his first papers appeared, Lang (*4*) and other investigators, including Bünsow and Harder (*5*), Lona (*6*), Lona and Bocchi (*7*), Marth, Audia, and Mitchell (*8*), and Wittwer and associates (*9*), reported on the initiation or promotion of reproductive development by gibberellin in various other species of plants. Of the 38 species studied, 17 have been long-day annuals, 9 biennials, 9 day-neutral annuals, and 3 short-day annuals. Gibberellin has proved to be a substitute for long-day and cold treatments for all species in the first two groups, except rye and *Perilla*. While induction of reproductive development was not involved in the day-neutral species, gibberellin hastened flowering in all species studied except pepper and geranium. No success has been reported, however, with the few short-day species studied. Lang (*4*) found that Biloxi soybeans and *Xanthium*, when treated with gibberellin, remained strictly vegetative under long photoperiods. Marth, Audia, and Mitchell (*8*) observed earlier blooming in gibberellin-treated saliva, but the plants were apparently already induced. Lang (*4*) reached the following conclusion: "It thus appears that application of gibberellin allows numerous plants to overcome cold and long day requirements in flower formation but that it does not substitute for any short day requirement."

The present study, which was initiated before the publication of Lang's results with soybeans and *Xanthium*, was designed to secure information on possible effects of gibberellin on the reproductive development of *Xanthium pennsylvanicum*, which is one of the best known short-day species. A preliminary experiment, in which both gibberellin-treated plants and controls were kept continuously under both long and short photoperiods, confirmed Lang's observations that gibberellin would not induce reproductive development in *Xanthium* under long photoperiods.

In the experiment reported here all plants were kept under long photoperiods (18 hour minimum) for 28 days following the date of planting (15 July 1957). At that time 30 plants were set aside as controls and 30 were treated with gibberellin in the form of a $10^{-3}M$ solution of gibberellic acid (*10*) in 0.25 percent Dreft, each plant receiving 1 ml of the solution as drops applied to the leaves with a pipette. The controls were similarly treated with the 0.25 percent Dreft solution alone. Five controls and five treated plants were continued under long days, and 25 of each were placed under 8-hour photoperiods in the greenhouse by means of an automatic short-day device (*11*). After two photoinductive cycles, five plants of each group were returned to long photoperiods. This process was repeated on alternate days, providing groups of plants which had received two, four, six, eight, ten, and twelve photoinductive cycles. The data reported here was taken 21 days after the beginning of the short-day treatments.

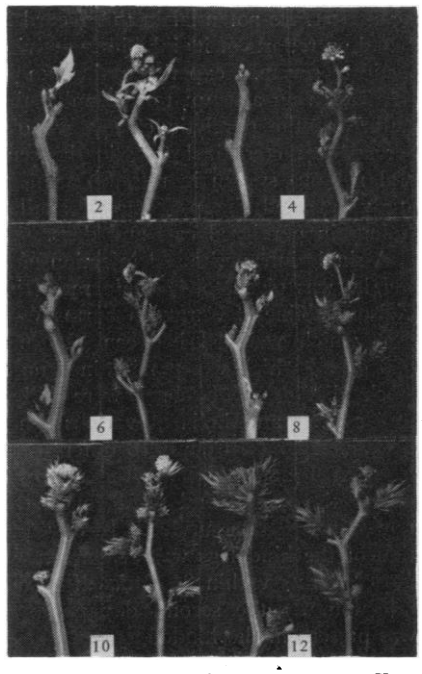

Fig. 1. Stem tips of representative *Xanthium* plants given 2 to 12 photoinductive cycles (figures between each pair of tips). The right-hand tip of each pair was from a plant treated with gibberellin, the left-hand tip from a control plant (× ½).

Table 1. Influence of gibberellin and photoperiod on the growth and reproductive development of *Xanthium pennsylvanicum* during a 3-week period after treatment.

Number of photoinductive cycles	Mean stem growth (cm)		Number of nodes visible		Inflorescence buds formed	
	Controls	Gibberellin	Controls	Gibberellin	Controls	Gibberellin
0	27.0	54.7	5	8	–	–
2	25.6	62.3	5	8	–*	+†
4	17.0	55.1	4	8	–*	+
6	20.6	66.7	5	8	+	+
8	15.6	57.2	5	7	+	+
10	18.9	57.4	4	7	+	+
12	15.7	50.1	5	6	+	+

* Inflorescence primordia present in all five plants.
† Four plants with macroscopic inflorescence buds, one with inflorescence primordia.

The stem growth of the gibberellin-treated plants was much greater than that of the controls in all photoperiodic treatments (Table 1), the gibberellin overcoming the reduction in stem growth produced in the controls by four or more photoinductive cycles. All gibberellin-treated plants had more nodes than the controls, though this may have been due to accelerated internode elongation rather than to the formation of additional nodes. Stem diameter was