devoid of MAO inhibitory activity. We have isolated from human blood, human brain, and rat brain substances of the same molecular weights that selectively inhibit either type A or type B MAO (*12*). In addition, if these CSF, blood, and brain samples are stored at room temperature for 72 hours prior to Sephadex separation, they no longer yield active fractions in the eluate.

These findings demonstrate that human CSF contains endogenous substances that act like MAO inhibitor drugs to inhibit both type A and type B MAO. These endogenous inhibitors of type A and type B MAO have different molecular weights and therefore probably are different substances. The type A MAO total inhibitory activity in CSF is six times as great as the type B MAO total inhibitory activity. These substances may have different degrees of control over type A MAO as compared with type B MAO.

As far as we know, this is the first isolation of endogenous inhibitors of MAO from the central nervous system. There is at present no evidence that links the inhibitory substances we have isolated to any clinical condition or to a dynamic regulation of MAO activity; only by direct study of the effects of these substances in animals and man will their physiological significance be determined.

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Evidence for Olfactory Function in Utero

Abstract. *Pregnant rats received 2-[^{14}C]deoxy-D-glucose (2DG) intravenously on the last day of gestation, and their fetuses were delivered 1 hour later by cesarean section. Fetal brains showed high 2DG uptake spread throughout the accessory olfactory bulb and little or no differential uptake in the main olfactory bulb. These findings demonstrate that functional activity occurs in the accessory olfactory bulb in utero and suggest that the accessory olfactory system may be the pathway by which fetal rats detect the odor quality of their intrauterine milieu.*

Our understanding of the main olfactory system has been increasing rapidly in recent years through the use of a variety of experimental techniques (*1*). Knowledge of the accessory olfactory system is much more limited. Although behavioral studies have implicated the accessory olfactory system in several important vertebrate behaviors (*2–4*), there have been few investigations of the physiological properties of this system (*5*). In the course of a developmental study of the rat olfactory system, we have used the 2-deoxy-D-glucose (2DG) method in utero and have obtained evidence for functional activity in the accessory olfactory bulb before birth.

The accessory olfactory pathway arises from receptors in the vomeronasal organ, which lies within a cartilaginous cavity in the fetal rat and is situated in the ventral portion of the nasal cavity. These receptors have an adult appearance at birth (*6*). This accessory pathway is anatomically distinct from the main olfactory pathway (*7*), which originates from receptors in the olfactory epithelium lining the nasal cavity; this epithelium also appears mature at birth (*8*). Figure 1 illustrates a frontal section of a newborn rat's main and accessory olfactory bulbs, where synapses of the main olfactory and vomeronasal nerves, respectively, are made. Although the laminae are not as distinct as in the mature olfactory bulb, the characteristic laminar pattern of each bulb is apparent. At birth, all the major cell types of the main and accessory olfactory bulbs are present, including mitral, tufted, granule, and periglomerular cells (*9*). Cortical projections of the main and accessory olfactory bulbs develop earlier in the rat (*10*) than the corresponding projections in hamsters (*11*). Therefore, anatomical considerations in rats indicate that each pathway has structural features that may allow them to function early in development.

Recent behavioral studies suggest that fetal rats are sensitive to the odor quality of amniotic fluid (*12*). Odor molecules dissolved in amniotic fluid could reach main olfactory and vomeronasal receptors by fetal respiratory movements, fetal swallowing, or passive diffusion. To test whether one or both of these pathways are stimulated in utero, we used

the 2DG technique, which has previously been used successively in studying postnatal developing olfactory pathways (*13–15*).

Four awake, pregnant Sprague-Dawley rats were injected intravenously with 300 μCi of [^{14}C]2DG per kilogram of body weight in the morning of embryonic day 22 (E22) (*16*). One hour later the dam was decapitated, and five fetuses were immediately delivered by cesarean section. The brain of each fetus was removed and prepared for autoradiographic analysis according to the standard Sokoloff method (*17*).

The radiographs of all fetal brains showed 2DG uptake, indicating that [^{14}C]2DG passed from maternal to fetal circulation. Figure 2A is a typical autoradiograph of a section from a fetus at the same level as shown in Fig. 1. Within the olfactory bulbs, regional variation of 2DG was apparent. Relatively high 2DG uptake was localized to the dorsolateral portion of the bulbs. In contrast, less dense areas of uptake were present in superficial laminae of the lateral and medial borders of the bulb. Little differential 2DG uptake was evident in the deep laminae of the main olfactory bulb.

An outline of the corresponding stained section (Fig. 2B), including the inner border of the mitral cell layer of the main olfactory bulb and the inner border of the mitral-granule cell layer of the accessory olfactory bulb, has been superimposed on the autoradiograph (Fig. 2C). This histological correlation indicates that the high 2DG uptake in the dorsolateral bulb is associated with the accessory olfactory bulb. Whereas this uptake appeared throughout the entire glomerular sheet of the accessory olfactory bulb, where the vomeronasal nerves terminate, the highest level of 2DG uptake appeared to be centered over the mitral-granule cell layer.

Correlations of 2DG autoradiographs with olfactory bulb histology, similar to those in Fig. 2, indicated that areas of high 2DG uptake in the dorsolateral position in the autoradiographs were associated with the accessory olfactory bulb in 18 of 20 fetuses (*18*). In contrast, in the main olfactory bulb, no clear foci of increased 2DG uptake were observed. Areas of relatively low 2DG uptake spread in a rostral-caudal direction in the medial and lateral portions of the main olfactory bulb in 16 of 20 fetuses. In the other four fetuses (19), 2DG uptake was relatively high in dorsocaudal regions of the glomerular sheet of the main olfactory bulb, a region that usually shows

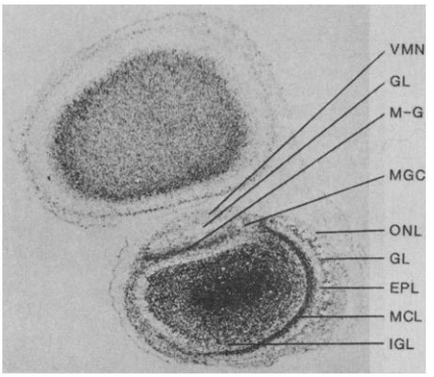

Fig. 1. A unilateral frontal section (10 μm) of the brain of a 1-day-old rat (*24*) with the frontal cortex seen dorsally showing the laminar appearance of the accessory and main olfactory bulbs. In the accessory olfactory bulb: *VMN*, vomeronasal nerves; *GL*, glomerular layer; and *M-G*, mitral-granule cell layer. At the junction of the accessory and main olfactory bulbs is the modified glomerular complex (*MGC*) (*14*). In the main olfactory bulb: *ONL*, olfactory nerve layer; *GL*, glomerular layer; *EPL*, external plexiform layer; *MCL*, mitral cell layer; and *IGL*, internal granule layer.

uptake in postnatal rat pups given 2DG and exposed to odors (*13, 15*).

To confirm the relative distribution of 2DG uptake within a section, autoradiographs were scanned by a computer image analysis system that was programmed to color code four different levels of optical density (2DG uptake) (*20*). Figure 2D shows a black and white photograph of a computer scan of the autoradiograph in Fig. 2A. The region indicated by lines 1 in Fig. 2D has the highest optical density within this section and, as is evident from the corresponding stained section (Fig. 2B), is associated with the accessory olfactory bulb region. This objective analysis thus confirms our finding that the accessory olfactory bulb has the highest 2DG uptake.

Since 2DG is considered to indicate neuronal activity (*21*), our findings support behavioral evidence that olfactory functioning occurs in utero. High 2DG uptake does not occur during odor stimulation in the accessory olfactory bulb ex utero (*13, 15, 22*). This may be a problem of stimulus accessibility to the receptors. The vomeronasal organ, at its rostralmost end, has access to the nasal cavity. Odors entering the nasal cavity must be sucked into the vomeronasal organ, presumably by a vascular pumping mechanism, in order to reach vomeronasal receptors (*23*). Similarly the prenatal lack of high 2DG uptake in the main olfactory bulb may reflect the absence of appropriate stimulus conditions for the main olfactory epithelium in utero. Thus, birth becomes a significant event because odor stimuli change from a liquid to a gaseous medium. The olfactory system may meet these dramatic changes in

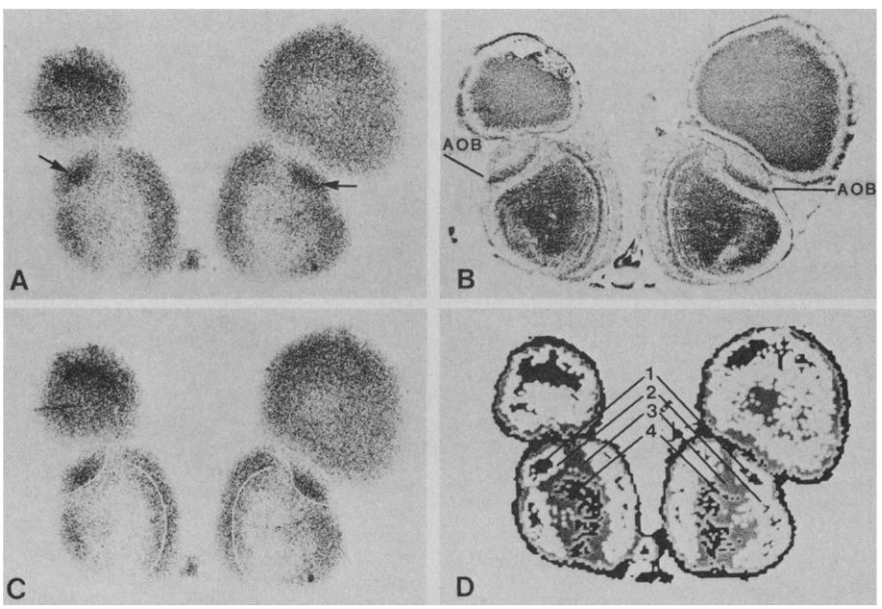

Fig. 2. Bilateral sections (32 μm) of the brain of a fetal rat (E22) with the frontal cortex seen dorsally. (A) Typical autoradiograph of a brain of a fetal rat that received 2DG from maternal circulation in utero. The arrows indicate the area of highest 2DG uptake. (B) Corresponding histological section stained with cresyl violet. The arrows indicate the lateral borders of the accessory olfactory bulbs (*AOB*'s). (C) Histological correlation. The area of highest 2DG uptake is centered over the accessory olfactory bulb. (D) Black-and-white photograph of a computer-assisted density scan of the autoradiograph in (A). The area marked by lines 1 has the highest optical density and is in the region of the accessory olfactory bulb.

odor stimuli by switching from the accessory olfactory pathway that can detect odors dissolved in a liquid medium to the main olfactory pathway that detects airborne odors.

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16. The day of copulation counted as day 0 of gestation. On the morning of E22, the pregnant rat was removed from the home cage, placed in a restrainer, and administered [^{14}C]2DG (50 to 60 Ci/mmole) in physiological saline (300 μCi) through the tail vein.
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18. Two fetuses had poor histological sections and therefore unclear autoradiographs. Thus, technical limitations made it difficult to assess whether 2DG uptake occurred in the accessory olfactory bulb. However, at the level of the present analysis, the remaining 18 fetuses consistently exhibited 2DG uptake in the accessory olfactory bulb (Fig. 2).
19. There appeared to be no consistent factors (sex was not determined in this study) that accounted for this result.
20. The procedure for 2DG image analysis is similar to that described by C. Goochee, W. Rasband, and L. Sokoloff [*Am. Neurol.* **7**, 359 (1980)]. The autoradiographs of fetuses were analyzed at Image Processing System, of Drexel University and the University of Pennsylvania.
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24. One-day-old rat received an intracardiac perfusion of 2 ml of 0.9 percent NaCl and 10 ml of Bouin's solution at room temperature. Routine procedures were followed for obtaining paraffin-embedded, cresyl violet–stained 10-μm sections of the olfactory bulb.
25. This research was supported in part by NINCDS grants F32-NS06978 to P.E.P. and NS 16993 to G.M.S. and W.B.S.

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Accurate Visual Measurement of Three-Dimensional Moving Patterns

Abstract. *Human observers discriminated relative three-dimensional distances in simple patterns of motion parallax with an acuity similar to vernier acuity under comparable conditions. Accurate visual measures of three-dimensional distance can be derived from the structural invariance of patterns undergoing perspective transformations.*

A principal function of vision is to measure the environment. Virtually all visual tasks involving either visual-motor coordination or recognition of objects require geometric information. Everyday observations of human athletes and other rapidly moving animals suggest that such visual measurements are usually very accurate. Controlled laboratory evaluations of vernier "hyperacuity" (*1*), of stereoscopic acuity (*2*), and of the rapid recognition of three-dimensional (3-D) structure in moving patterns (*3*) also indicate that vision provides precise geometric information under some conditions.

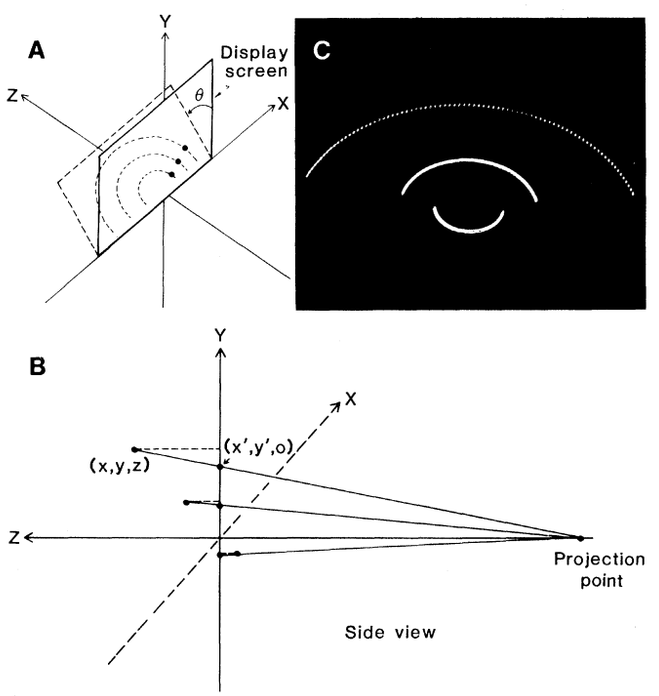

Fig. 1. Stimulus patterns. (A) Schematic illustration of CRT displays of three collinear dots rotating as if in a plane tilted in 3-D space. (B) Schematic side view of the perspective projection, drawn to scale for the first experiment. The distance of the perspective projection point from the center of rotation was 2.5 times the distance between the two endpoints. (C) Time-lapse photograph of one of the CRT displays, showing the complete paths of three equally spaced points rotating through 160° in the 45°-tilt condition. In the first experiment the rotation was through an angle of 160°. The visual subtense of the distance between the two endpoints was 1.02° in the 0° tilt condition of the first experiment; with 30°, 45°, and 60° of tilt the projected distance between the endpoints in the perspective displays was reduced to a minimum of 0.89°, 0.70°, and 0.48° visual arc, respectively, at the middle of the path. The displays were viewed monocularly in the dark from a distance of 94 cm. The temporal duration of each rotation in the first experiment was 0.94 seconds, and each trial consisted of four successive rotations. In subsequent experiments, performance was essentially unimpaired with the use of a single rotation through an angle of 120° over a temporal duration of 0.47 seconds. Observers responded to each display as centered or displaced, and auditory feedback was given for each correct response.