the separation of normal bull semen into plasma and sperm with subsequent reconstitution appears to have no detrimental effect upon the ability of the sperm to metabolize fructose. 2. Similar results were obtained when semen from three normal bulls was intermixed. 3. The immediate administration of testosterone propionate to a bull at the time of castration prevents the loss of seminal fructose resulting from castration. Seminal plasma from such an animal was not fully capable of maintaining the metabolism of fructose by normal sperm. 4. Seminal plasma of negligible fructose content from a bull in which castration changes were allowed to develop before testosterone therapy was begun failed to support a normal rate of fructolysis since only 20 per cent of added fructose was utilized by normal sperm. Testosterone therapy caused a marked increase in both seminal fructose and the utilization thereof. Subsequent withdrawal and resumption of steroid therapy produced similar results. Thereafter, in spite of continued treatment with testosterone, the seminal plasma of this castrate only partially supported fructose metabolism. 5. Vasoresection in a bull had no adverse effect on either sex drive or the production of seminal fructose. However, when normal sperm was transferred to seminal plasma from this bull, the utilization of fructose was, contrary to expectations, markedly reduced. This would indicate that vasectomy adversely affects the functional status of the accessory sex organs.

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Development of Electrical Activity in the Cerebral Cortex of the Albino Rat.* (19773)

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Rhythmical electrical activity appears rather suddenly in the cerebral cortex of the guinea pig during the seventh week of gestation(1,2). Various morphological and biochemical changes also occur at this particular stage of development in this animal(3,4). The present study is concerned with an attempt to determine the critical period, for the albino rat, at which the cortical neurons become functionally active, using the electrocorticogram as an indicator of this development.

Methods. About 50 albino rats of various ages from the newly born to the adult were studied. Ether, diallylbarbituric acid (25-50 mg/kg, I.P.), or d-tubocurarine chloride (0.2-1 mg/kg, I.P.) were used to immobilize the animals in order to permit direct recording of electrical potentials from the cerebral cor-

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tex. Artificial respiration was administered, by means of short bursts of air from a mechanical pump into a tracheal cannula, before curarization. (Cannulae suitable for the young animals were fashioned out of standard No. 20 hypodermic needles). As long as this ventilation was adequate, cortical electrical activity was not seriously affected even after complete muscular paralysis(5-7). Surgical procedures, *e.g.*, tracheal cannulation, exposure of the cortex, were performed under ether anesthesia. The entire procedure was carried out in a large tray maintained at about 37°C and the exposed skull or cortex was periodically moistened with warm mammalian Ringer-Locke's solution.

A 3-channel, Offner D-C amplifier (based on a carrier-wave, chopper circuit) and operating ink-writer were used in conjunction with a battery-operated, differential type, cathode-follower input stage. The entire instrument therefore constituted a direct-coupled amplifier with a maximum sensitivity of about 250 μv per cm pen deflection, and a frequency response, uniform to within 10%, from 0 to about 40 cycles per sec, and falling off by 60% at 75 cps. The paper drive could be run at various speeds from 0.5 to 25 mm/sec.

The recording electrodes consisted of Ag-Ag Cl wires dipping into pipettes filled with Ringer's solution, and making contact with the tissue via cotton threads protruding from the pipette tips. Bipolar recording was used most frequently, with a large Ag wire inserted into the mouth for a ground electrode. Spurious changes of potential between these pairs of recording electrodes were routinely monitored by connecting the pair through a piece of Ringer-moistened filter paper. Control of artifacts due to movement of the cortex with respect to the electrodes was made by recording simultaneously from an active and a nearby surgically or chemically inactivated area.

Strychnine was applied to the cortex either in the form of a small crystal of strychnine sulfate or on a small piece of filter paper soaked in a 2% solution of that salt.

Results. During the first week after birth, the electrical activity detectable from the cerebral cortex was irregular, intermittent, and of relatively low amplitude. "Silent" periods were common. The frequencies tended to be of the order of several cycles per second. From the fourth day onward, local application of strychnine resulted in the appearance of spike potentials of the order of several tenths of a millivolt and about 0.5-1 sec. in duration. These usually developed within a few minutes after the application, and occurred, irregularly, several times per minute. By the seventh day, spikes so evoked were as large as one millivolt, and their durations less than 750 msec. They also occurred more frequently, *i.e.* once every several seconds.

Between the seventh and tenth days, a marked trend towards regularity, rhythmicity, and continuous activity was seen in the records. Silent periods were almost nonexistent by the tenth day. The amplitudes were often as large as several tenths of a millivolt, while the frequencies varied from several to about 20 per sec. Strychnine-induced spikes were now of still shorter duration—about 250-500 msec, and occurred more frequently—sometimes as often as several per sec.

The developments in the ECoG patterns subsequent to the tenth day were relatively minor. By the fourteenth day the amplitudes were somewhat larger, both with regard to spontaneous as well as strychnine-induced activity. Moreover, the duration of the strychnine spikes decreased to about 100 msec. The patterns observed at this age level were basically similar to those of the adult rat.

In a few cases, the entire surface of the cortex was explored for differences in the rate of development of electrical activity, but no significant differences were detected. In general, it was found that the largest amplitudes were obtained from the frontal and parietal regions.

In some cases, the cortex was locally inactivated, either by cutting a circle in the cortex about 2 mm deep, or by applying a piece of filter paper soaked in a 2% solution of Nupercaine (x-butyloxycinchoninic acid-γ-diethylethylenediamide hydrochloride). Within a few minutes, most of the electrical activity disappeared in that region.

Discussion. The fact that local application

of strychnine to the cortex resulted in typical spike activity indicates that at least part of the spontaneous electrical activity described above arises from cortical cells(8). The lack of appreciable pickup from subcortical regions is also shown by the results of local inactivation of the cortex.

Many morphological changes occur in the rat cerebral cortex between the 5th and 10th days after birth. Sugita found that the thickness and volume of the cortex increased sharply during this period, while the number of cortical neurons per unit volume decreased rapidly, all three parameters suddenly approaching the adult levels on about the 10th day(9,10). He also observed that the nuclei and nucleoli of the cortical neurons suddenly reached their maximum size on this day. Furthermore, Nissl bodies first appeared on the 9th day and gradually became more abundant. Tilney(11) also found relatively little cellular or histological differentiation during the first week after birth and marked development during the second week. His observations of the behavior patterns of 5- and 10-day-old rats showed that little if any were of such complexity as to imply a cortical level of neural correlation. The exploratory and playful activity of the 15-day-old, however, could no longer be reasonably ascribed to infracortical levels of correlation. It is interesting to note that the appearance of continuous, regular, rhythmical electrical activity in our experiment coincides very closely with the end of the period of rapid cellular and histological maturation in the rat cortex. The spike potentials elicited by strychnine also approach their adult form soon after this time.

These results agree well with ECoG studies on kittens(12) and young rabbits(13,14). In the guinea pig cortex, it has been shown that the period of rapid morphological development occurs between the 41st to 46th days of gestation(3,4). The analogous period in the rat occurs between 7 to 10 days after birth. In the guinea-pig, however, well-developed, spontaneous, as well as strychnine-elicited, cortical activity appear suddenly on the 46th day of gestation, whereas none could be detected on the 45th day(2). The more gradual development of electrical activity in the rat, cat, and rabbit, beginning well before most of the cortical cells have undergone appreciable maturation, may be related to the multitude of new stimuli that impinge upon these postnatal animals resulting in the acceleration of the development of certain critical processes necessary for the appearance of such activity. In spite of this difference, however, the fundamental cortical developmental processes are essentially the same in both groups.

Summary and conclusion. 1. Electrocorticograms were recorded from albino rats immobilized with various drugs. 2. Spontaneous electrical activity was irregular, intermittent, and of relatively low amplitude during the first week after birth. 3. Local application of strychnine to the cortex resulted in large, slow, spike potentials in rats several days old. 4. The general trend in the spontaneous activity from birth to about 10 days of age was towards increasing rhythmicity, regularity, continuousness, and amplitude. The strychnine-induced spikes gradually decreased in duration, and increased in amplitude and frequency of occurrence. 5. The ECoG of the 10-day-old rat was already basically similar to that of the adult.

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