consequently no detailed consideration will be given it here. It might be pointed out, however, that this mechanism, based primarily on the nonrandom disjunction of heteromorphic homologues in *Drosophila,* would adequately account for the age effect described here by attributing it to a decreasing level of crossing over with increasing age and would also account for interracial differences as a reflection of the degree of structural heterozygosity in those races.

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Manuscript received September 8, 1952.

Hibernation and Cortical Electrical Activity in the Woodchuck (*Marmota monax*)[1]

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Previous work from these laboratories showed that spontaneous cortical electrical activity could not be recorded in the golden hamster arousing from hibernation until the cortical temperature had reached 19°–21° C (*1*). These studies, extended to the woodchuck (*Marmota monax*), reveal profound differences between this hibernator and the hamster in regard to the electrocorticogram and in the behavior of the animal during hibernation.

In the present experiment the electrocorticogram and the cortical temperature were recorded by means of a device that had been previously attached to the skull. This device was made throughout of stainless steel and consisted essentially of a plate $1 \times 1 \times 0.1$ cm, which was drilled at each corner to receive screws and drilled and threaded in the center to receive the electrode and thermocouple carrier. The carrier was a short, L-shaped tube of 0.15 cm outside diameter, threaded on one end to screw into the central hole of the plate, and containing 2 silver electrodes and an iron-constantan thermocouple. The electrodes protruded slightly from the end of the threaded tube, and the inside of the tube was filled with polyethylene.[3] All wires were coated with the same substance.

To attach the device, the skull of a woodchuck, which was hibernating in a cold room kept at 3°–7° C, was exposed under sterile conditions, and the plate fastened

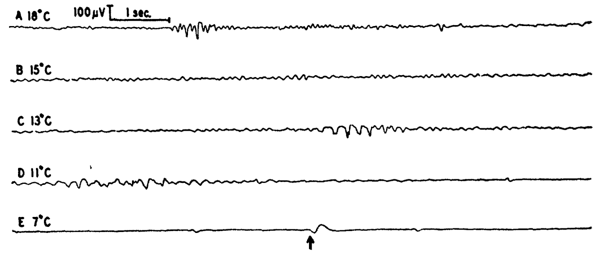

FIG. 1. Electrocorticograms of a hibernating woodchuck at various cortical temperatures as indicated. The arrow in record *E* indicates a cortical response evoked by noise. Other deflections in record *E* are artifacts from EKG. Calibration in record *A* applies to all.

to the skull by the screws. A hole was then drilled in the skull through the central opening of the plate and the carrier screwed in place so that the electrodes rested on the dura. The wires from the thermocouple and electrodes were forced through the subcutaneous tissue and brought out through the skin of the interscapular region. The incision in the skin of the head was then closed over the device. Cortical temperature was measured by a Micromax thermoelectric recorder. The operative procedure, which did not require anesthesia because the animal was hibernating, caused the animal to awaken gradually with a concurrent increase in body temperature. Five days later, when it was observed that the animal was re-entering hibernation, recording of cortical activity (on a Grass ink-writer) was started and continued intermittently for 18 days. During this period the animal's cortical temperature fluctuated between 6° and 35° C.

Since a cortical response could easily be evoked by auditory stimulation, even at cortical temperatures as low as 7° C, it was concluded that the electrodes had been placed on an auditory receiving area (Fig. 1 *E*). Slow, nondescript, spontaneous cortical activity could also be recorded at this temperature, although it was sporadic. At 11° C and above, spontaneous burst activity was apparent, and the components of the bursts increased in frequency as the temperature rose (Fig. 1 *A–D*). Adequate recordings at temperatures higher than 18° C were precluded by the large number of muscle artifacts caused by the tensing and movement of the animal.

These observations are reported at this time because Kayser and his co-workers (*2, 3*) have recently recorded spontaneous cortical activity in the hibernating and artificially cooled ground squirrel at deep body temperatures of 5°–6° C and have commented upon how different their results are from those described by us in the hamster, without suggesting that species differences might explain the discrepancy. Like the ground squirrel, the woodchuck shows spontaneous cortical electrical activity at body temperatures at which it is completely absent in the hamster. Furthermore, the woodchuck shows an evoked auditory cortical potential at temperatures at which the auditory nerve of the hamster does not conduct (*4*). The general pattern of hibernation in the woodchuck also differs

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profoundly from that of the hamster, as the woodchuck is capable of responding to auditory and mechanical stimulation by moving about at body temperatures at which the hamster is completely immobile.

The recorded differences in the electrocorticogram of the hibernating ground squirrel and woodchuck as contrasted with the hamster emphasize that generalizations about physiological processes which occur in hibernating mammals should be guarded and that the species should always be indicated.

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Manuscript received September 17, 1952.

Observations on a Class of Free Radicals Derived from Aromatic Compounds[1]

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The reaction of alkali metals with aromatic hydrocarbons has been under investigation for many years. It was not until 1935, however, when it was found that ethers such as methyl ether or 1,2-dimethoxyethane promote the reaction (*1, 2*), that significant progress was made toward an understanding and utilization of the reaction.

It has been suggested (*2–5*) that the reaction of an alkali metal with an aromatic hydrocarbon in the presence of one of the above ethers involves the transfer of either one or two electrons from alkali metal atoms to one molecule of hydrocarbon. We have found that the intensely colored substances formed upon reaction of sodium with naphthalene, anthracene, naphthacene, 1,2-benzanthracene, 20-methylcholanthrene, nitrobenzene, *m*-dinitrobenzene, 1,3,5-trinitrobenzene, or 2,3,7-trinitrofluorenone, in 1,2-dimethoxyethane or tetrahydrofuran as solvents, exhibit intense paramagnetic resonance absorptions.[2,3] In none of these paramagnetic products does the gyromagnetic ratio deviate from the free electron value by more than a few tenths of 1%. It is difficult to reconcile these observations with the suggestion that the reaction involves the transfer of two electrons from two atoms of sodium to one molecule of aromatic compound. This hypothesis would require that in each case the normal state of these paramagnetic molecules is a triplet (biradical) electronic configuration. Such a situation is highly unlikely in molecules in which orbital degeneracy does not exist. All the molecules under discussion here belong to the class in which no orbital degeneracy is permitted.

These considerations, in addition to the fact that the over-all reaction involves one aromatic molecule per atom of sodium (*1, 2*), indicate that we are dealing with free radical ions formed by the transfer of one electron to the aromatic compound. The reaction, using naphthalene as an example, may be represented by the equation:

$$Na + C_{10}H_8 \leftrightharpoons Na^+ + (C_{10}H_8)^-.$$

The analogy between this equation and the equations for the solution of sodium in liquid ammonia and triphenylmethyl in liquid sulfur dioxide is worth noting.

Scott, Walker, and Hansley (*2*) demonstrated that the reaction is an equilibrium. They also pointed out that methyl ethers, such as dimethyl ether or 1,2-dimethoxyethane, are very effective in shifting the above equilibrium to the right, whereas ethyl ether, for example, is relatively ineffective. It is believed that, in general, it is the magnitude of the energy of solvation of the metal ion (and perhaps also the negative hydrocarbon ion) by the ether which is the principal factor in determining the value of the equilibrium constant for the above reaction. It then follows that ethers which are relatively unhindered sterically (*6*), or polyethers which can form chelate structures with the metal ion (*4*), will be most effective in shifting the above equilibrium to the right. This conclusion is in agreement with the qualitative experimental data that are available.

The shape of the paramagnetic resonance absorption curve is dependent on the particular free radical and on its concentration. The hydrocarbon free radicals at concentrations in the neighborhood of 10^{-4} *M* yield a single absorption band about 5 oersteds wide. As the concentration is increased from this value, the band width decreases. Absorption bands narrower than 1 oersted are observed at high concentrations (*ca.* 0.1 *M*). The only mechanism thus far suggested for such a narrowing involves an exchange of spins between free radical molecules, the exchange proceeding because of orbital interaction (*7*). The fact that this narrowing is observable at concentrations of the order of 10^{-3} *M* indicates that the orbital interaction in these molecules may be exercised at large distances.[4]

The paramagnetic absorption spectra of the nitro-free radicals, with the exception of the fluorenone derivative, exhibit remarkable structures in dilute solutions. From 1,3,5-trinitrobenzene a free radical is obtained whose absorption shows 8 symmetrically distributed, evenly spaced peaks. Nitrobenzene and *m*-dinitrobenzene each yields a free radical whose absorption has 10 peaks; the relative intensities of the peaks in each pattern are different for the two compounds. The absorption in each case covers about 25 oersteds.

[1] Assisted by the joint program of the Office of Naval Research and the Atomic Energy Commission.

[2] Our observations were made at 9000 megacycles/sec in fields in the neighborhood of 3200 oersteds.

[3] We are indebted to the U. S. Industrial Chemicals Co., Division of National Distillers Products Corporation, for the sodium dispersion used in many of our experiments.

[4] The average separation between molecules at 10^{-3} *M* is about 100 A.