reference plates of the base line was effected by means of an accurate steel straight edge placed in line with and parallel to the mirror faces. The remaining necessary distances between mirrors were measured by steel tapes. Allowance was made for window thickness and air distance from the window to the rotating mirror. The mean paths were 12,811.204 and 15,999.744 meters for the 8- and 10-mile paths, respectively. Fifty-six measures of the base line were made.

The results of the several series of observations are listed in Table I.

TABLE I

Series	Date	Number of determinations	Velocity of light	Average deviation
1– 54	1931—Feb. 19 to July 14 ...	493	299,770	12
1– 56	1932—Mar. 3 to May 13 ...	753.5	780	11
57–104	1932—May 13 to Aug. 4	742	771	9
105–179	1932—Dec. 3 to 1933, Feb. 27	897	775	11
		2,885.5	**299,774**	**11**

The simple mean of the 2,885.5 separate determinations gives for the velocity of light in vacuo 299,774 km/sec. The average deviation (A.D.) given in the table is that of a single series from the mean of the group. A plot of the weighted velocity readings with respect to time shows the following characteristics. The mean velocity for 1931 is 299,770 km/sec. The mean value for the series 14–25 is 299,746 km/sec. while the value for the remainder of the year lies close to 299,775 km/sec. The mean values for the first 56 series of measures for 1932 is 299,780 km/sec. and that for series 57–104, ending in August, 1932, and including approximately the same number of observations, is 299,771 km/sec. If the readings be taken in small groups and the means plotted, the curve through these points starts early in March at 299,784 km/sec., runs slightly above the axis until early in May and then drops to 299,768 km/sec. early in June. Several fluctuations appear in the curve at this time. The curve remains below the axis until observations stopped on August 4. The mean value for 1932–33 is 299,775 km/sec. The curve starts early in December at 299,785 km/sec., crosses the axis about January 1 and reaches a value of 299,765 km/sec. about January 15. It then gradually rises to 299,787 km/sec. late in February. When the velocities were first plotted, each evening's observations were taken as a unit. A curve freely drawn through these points resembled somewhat the tide curve of the water depths at the nearby coast at a lunitidal interval of 10 hours later. To check this apparent relationship sun-moon tide curves were drawn by the U. S. Coast and Geodetic Survey on their tide-predicting machine and careful comparisons were made of the various components of the tide curves with the velocities. The best correlation seemed to be one between velocity and the horizontal component of the tide force perpendicular to the tube, the velocities being high for a strong tide force pulling in a southeasterly direction and low for a northwesterly direction. The dispersion of readings, however, is great, and consequently little weight can be attached to this relation. The same may be said regarding a plot of velocities and moon diameters. Independent plots of both the early 1932 and the 1932–33 observations each show the same feature, namely, that the velocity is high when the diameter is either large or small, suggesting tidal effects. The scattering, however, is large and the results questionable. The formation of the weighted mean curve has, however, eliminated most of the apparent periodic fluctuations. Repeated measures of the base line and checks on the clock rate showed no changes capable of producing the residual differences between the mean curve and the axis. A vibration of the mirror system with a period equal to a fraction of that of the rotating mirror conceivably may have produced the rapid fluctuations observed in the individual readings.

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EXPERIMENTAL STIMULATION DEAFNESS

IT has frequently been reported, and also denied, that prolonged exposure of animals to loud tones causes histological damage to the organ of Corti or loss of sensitivity to sounds as judged by conditioned reflexes. Recently the electrical responses of ear and auditory nerve have also been employed in this type of experiment as additional indicators of possible damage.[1] During the past two years, we have exposed five groups of animals (cats and guinea-pigs) to tones of 600, 800 or 2,500 c.p.s. and examined them by one or more of these methods. We believe that our results throw some light on the variability apparent in previous reports.

In testing auditory function of anesthetized animals by the electrical response, we pick up an electrical potential at the round window and observe the amplified electrical waves with a cathode ray oscillograph. The intensity of sound necessary to cause a just-visible deflection is taken as threshold. The sensitivity of normal cats and guinea-pigs determined by this method corresponds quite closely to the normal human audibility curve and is in excellent agreement with our own and with Horton's[2] determinations of the sensitivity of guinea-pigs by the method of conditioned reflexes. This justifies the use of the electrical method in testing auditory function.

[1] E. G. Wever, C. W. Bray and G. P. Horton, "The Problem of Stimulation Deafness as Studied by Auditory Nerve Technique," SCIENCE, 80: 18–19, 1934.

[2] G. P. Horton, "A Quantitative Study of Hearing in the Guinea Pig (Cavia Cobaya)," *Jour. Comp. Psychol.*, 15: 59–73, 1933.

A preliminary group of 3 cats and 3 guinea-pigs was exposed to 600 c.p.s. at 85 db above human threshold for durations up to 2 months. They were tested electrically, and the guinea-pig ears were examined histologically. None of them showed significant deviations from normal or recognizable histological lesions.

A second group of 5 guinea-pigs was exposed to 800 c.p.s. at 95 db for 16 hours a day for durations up to 74 days. All these animals were equally normal by electrical test.

A third group of 13 normal guinea-pigs was exposed to 600 c.p.s., 9 at 65 db and 4 at 95 db for 70 and 75 days, respectively. They were tested by the conditioned-reflex method (Kemp[3]) at frequencies 400, 500, 600, 700 and 800 c.p.s. before and after exposure. One of the first 9 and all the second 4 animals showed slight losses of sensitivity amounting to not more than 20 db at most in this range. The other 8 remained normal. The animal most affected showed by the electrical method an average deficiency of 12 db over the entire range from 15 to 1,500 c.p.s., but was practically normal from 1,750 to 10,000 c.p.s. There was no specific loss at or near 600 c.p.s. Histological examination of this ear revealed degenerate external hair-cells in the organ of Corti scattered through the second, third and fourth turns. In no region were more than 25 per cent. of the cells abnormal.

Seven guinea-pigs, 3 exposed to a d_4 whistle (about 2,400 c.p.s.) at 97 db for 15 hours a day for 40 days and 4 to 2,500 c.p.s. at 106 db for 45 days, all showed loss of sensitivity electrically and degeneration of external hair-cells histologically. Three of the most severe cases showed maximal losses of 76 db, 52 db and 50 db, and also distortions of wave form in the response. The zone of greatest loss lay in each case between 1,200 and 1,800 c.p.s. Two of these animals on histological examination each showed in both ears extensive degeneration of external hair-cells and also a rupture of Reissner's membrane in the second and third turns. The animal with greatest loss showed similar degeneration of cells and also hemorrhage into the scala media. The remaining 4 guinea-pigs showed losses of sensitivity, varying in degree from 20 to 56 db, in the range from 750 c.p.s. to 1,500 c.p.s. In the mildest case the loss involved only this range, while in the most severe the entire range tested (60 to 10,000 c.p.s.) was involved. The loss in the latter case averaged 37 db from 70 to 250 c.p.s., 52 db from 375 to 1,500 c.p.s., 40 db from 1,750 to 5,000 c.p.s., and 20 db from 6,000 to 12,000 c.p.s. The other 2 were intermediate in degree, but essentially similar in type. Histologically all showed more or less severe degeneration of external hair-cells in a wider or narrower zone of the organ of Corti, centering in each case in the middle third of the second turn of the cochlea. The severity and extent of the lesion correlated closely with the degree and extent of abnormality of the audiogram. The transition from normal to abnormal was gradual, both in the audiogram and in the histological picture.

These results indicate that the frequency as well as the intensity of the exposure tone may be an important factor in determining whether or not the inner ear is damaged. Considerable individual differences in susceptibility are also indicated. Intense exposure may apparently cause extensive loss of hearing, although we have not yet encountered the type of extreme loss affecting the entire range equally, as described by Finch and Culler.[4] The gross internal damage to the inner ear in some of our cases shows that interpretation is impossible without proper histological examination. In experiments now in progress we hope to extend the correlation of losses shown by the electrical method with loss of response by the method of conditioned reflexes. It is somewhat surprising and difficult of explanation that the zone of greatest loss of sensitivity as determined electrically does not necessarily coincide in frequency with the exposure tone. The losses and also the pathological lesions are wide-spread, indicating that the resonance of the basilar membrane is not sharp, but the more favorable cases of moderate damage support the "place" theory of pitch perception and relate the frequency 1,200 c.p.s. with the middle of the second cochlear turn in the guinea-pig. This is approximately the middle of the audible range and also approximately the middle of the basilar membrane.

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[3] E. H. Kemp. In press.

[4] G. Finch and E. Culler, "Effects of Protracted Exposure to a Loud Tone," SCIENCE, 80: 41–42, 1934.

BOOKS RECEIVED

ALLEN, ARTHUR A. *American Bird Biographies.* Pp. ix + 238. 20 plates. 189 figures. Comstock. $3.50.

Anales del Museo Argentino de Ciencias Naturales, "Bernardino Rivadavia." Tomo XXXVII. Pp. xiv + 581. Illustrated. Museo Nacional de Historia Natural, Buenos Aires.

KRAUSE, ARLINGTON C. *The Biochemistry of the Eye.* Pp. xv + 264. 17 figures. Johns Hopkins Press. $3.25.

LUTZ, FRANK E. *Field Book of Insects.* Pp. 510. 800 illustrations. Putnam's. $3.50.

PENDRAY, G. EDWARD. *Men, Mirrors and Stars.* Pp. x + 339. 31 plates. 47 figures. Funk and Wagnalls. $3.00.