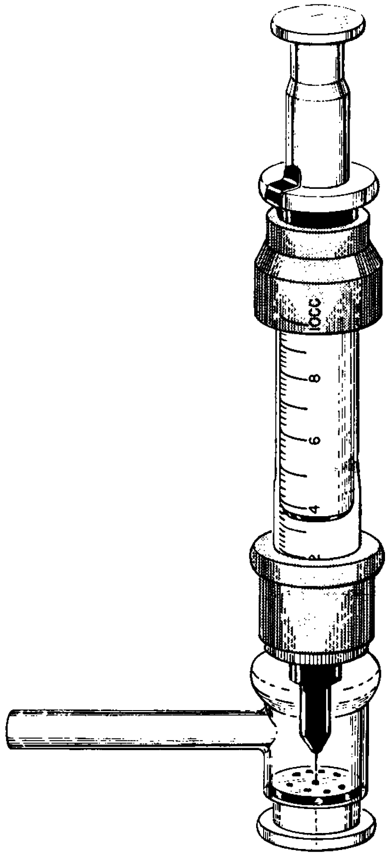

FIG. 1. Semiautomatic injection apparatus.

advantage that preliminary anesthetization or complete immobilization of the animal is not essential.

The apparatus illustrated in Fig. 1 was developed and tested in this laboratory. It consists of a glass tube with side arm, attached to a syringe. A perforated glass disk was sealed at a distance of $\frac{1}{4}$ in. from the end of the tube. A 26-gage, 1-in. hypodermic needle was attached to the syringe. The tube and syringe were connected by means of a ground-glass joint so that the end of the hypodermic needle extended out through the perforated disk. A screw connection in the position of the ground-glass joint could be substituted as a means of varying the length of projection of the needle.

In operation, the syringe is filled with the solution to be injected; it is then attached to the tube with a suitable length ($\frac{1}{4}$ in. was used in our experiments) of the hypodermic needle extending through the perforated disk into the open end of the tube. The open end of the tube is placed against the skin of the animal to be injected, and suction is applied by attaching the side arm of the tube to a water aspirator. The plunger of the syringe should be held in place during this time. The skin is sucked back against the perforated disk and the needle is thus automatically forced through the skin. The injection is then made subcutaneously by simply pushing the plunger in; then the suction is immediately released and the apparatus withdrawn.

Preliminary tests were made on the shaved belly of the rat. The apparatus was found to work very successfully if a sharp needle of the proper size is used. By connecting a suitable extension rod to the plunger of the syringe, injections could be made at considerable distances from the test animal. With slight modification (proper adjustment of the length of needle extending through the disk) intraperitoneal injections were possible.

The Informational Capacity of the Human Ear

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New concepts of the nature and measure of information (*1*, *4*) have made it possible to specify quantitatively the informational capacity of the human ear. A published estimate (*5*) gives 330,000 as the approximate total number of monaurally distinguishable tones of all frequencies and intensities. Dividing this figure by $\frac{1}{4}$ sec, the approximate average time necessary for the discriminations measured, 1.3×10^6 is arrived at as the total number of distinguishable tone choices the ear can make in a second. The same figure can be obtained by an independent calculation. An extrapolation of Gabor's data (*1*) on the efficiency of perception of "logons," or elementary signals, up to 16 kc gives an average of 18% of the total, or 5,800, as the number perceptible in 1 sec. Using the Riesz intensity discrimination data (*3*), a weighted average of 230 j.n.d.'s (just noticeable differences) of intensity for pure tones can be obtained, over the whole frequency range. If it is assumed that the number is the same for an individual logon, a total of $230 \times 5{,}800 = 1.3 \times 10^6$ distinguishable tones/sec is calculated, in complete agreement with the figure estimated by the first method.

To express the capacity of the ear in the conventional informational units of "bits" (binary digits)/sec, it is necessary to inquire how many of the distinguishable tones are independent of each other. A crude procedure is to assume that neighboring logons can be independently perceived. The total number of bits/sec will then be the product of 5,800, the number of logons/sec, by the average number of bits/logon. The latter figure is calculated from the Riesz data (*3*) to be 8.2, by taking the weighted average of the $\log_2$ of the number of intensity j.n.d.'s at each frequency. By this procedure, about 50,000 bits/sec is the estimated informational capacity of the ear.

Since neighboring frequencies are known to mask one another, this figure is certainly high. Wever's recent critical review (*7*) presents convincing evidence that the masking is due both to peripheral and central interference phenomena. However, calculation of the effect of mask-

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ing will be performed under the arbitrary assumption that it is due strictly to stimulation of a broad region on the basilar membrane, in accordance with a "place" theory of hearing. The calculated informational capacity depends only on the masking and intensity data, and is independent of which auditory mechanism is used.

On this basis, response of the ear at any time can be described by the "stimulation profile," a graph of stimulus intensity vs. position on the basilar membrane. It represents a sort of short period Fourier analysis of the sound along the membrane. The effect of the phenomenon which leads to masking of adjacent frequencies can be represented by stating that the derivative of the profile cannot exceed a certain value. Thus intense sounds "swallow up" faint ones at neighboring frequencies, because stimulus intensity decays insufficiently with frequency to allow the weak tone to be perceived.

At any point in the hearing region, a certain length along the basilar membrane will have to be traversed before a single intensity j.n.d. can be perceived. This can be called the masking distance, and is larger for low tones than for high ones, in general. With simplifying assumptions, the total number of distinguishable configurations possible to the stimulus profile can be counted. Using the Riesz intensity perception data (*3*), and averaging with the Wegel and Lane masking data (*6*), a length of about 0.04 mm on the basilar membrane is obtained as the average masking distance.

Any of three relations may be observed between two points separated by this distance on the profile. The point at higher frequency may be (1) the same intensity, (2) one j.n.d. more intense, or (3) one j.n.d. less intense than the lower frequency point. A simple calculation gives approximately $230 \times 3^{(32/.04)}$ as the total possible number of profiles, since there are 230 j.n.d.'s in the average intensity range, three choices of profile direction in one masking distance, and 32/.04 or 800 masking distances along the total basilar membrane. Hence, the total number of bits per profile is $\log_2 (230 \times 3^{800})$, or about 1,300 bits. Dividing by 1/6 sec, the time required for the intensity discrimination measurements, a figure of about 8,000 bits/sec is obtained for the informational capacity of one human ear.

Two assumptions cause this figure to be crude. First, it is likely that the use of intensity measurements of shorter duration than 1/6 sec would increase this figure, by allowing more profiles per sec to be possible, even though the amount of information per profile would decrease somewhat. Second, the use of a single averaged masking distance is subject to some error. Phase information, generally of no value except to binaural phenomena, is also neglected.

An important observation is that the dynamic range of the ear scarcely affects the final calculations. Only when the intensity range of the intelligence is cut down to 10 or 20 db is a sufficient fraction of the possible profiles ruled out to lower appreciably the informational capacity.

Since about 29,000 ganglion cells (*2*) are to be found in a cochlear nerve, we observe about 0.3 bit/sec of information per nerve fiber. This low figure naturally results from the lack of coding in the cochlear innervation. If the capacity is taken as 1.3×10^6 distinguishable tones/sec, then about 40 tones/sec can be accounted for by each fiber. This is about 10% of the maximum number of impulses which an adapted nerve fiber can carry.

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The Effect of Aureomycin on *Endamoeba histolytica* in Vitro

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Antibiotics obtained from molds or bacteria have shown thus far a very limited range of usefulness in diseases caused by protozoan parasites, with the exception of amebiasis. Good clinical results have been obtained in human infections with *Endamoeba histolytica* by the administration of penicillin (*1*), bacitracin (*6*), and aureomycin (*5, 6*), although it is inferred by some that improvement is due to the action of the antibiotics upon secondary bacterial invaders rather than directly on the amebas (*4, 6*). In the case of penicillin this seems to be substantiated by results obtained *in vitro*, in that no direct effect upon amebas was observed with levels as high as 30 Oxford units per ml for 48 hr (*4*). Gramicidin and subtilin were reported to be effective *in vitro*, and it was stated that subtilin lowers surface tension, causing rupture of the membrane of *E. histolytica* (*2*). In the course of a screening program *in vitro* for amebacidal substances in our laboratories, it was found necessary to evaluate the effects of antibiotics by a somewhat different procedure from that commonly used, in order to separate effects produced on amebas from bactericidal action against associated bacterial flora. These studies revealed that aureomycin produces what appears to be a direct effect on trophozoites of the strain of *E. histolytica* used.

The strain of *E. histolytica* used in this study was obtained through the courtesy of Charles Rees of the National Institutes of Health. It was designated as the NRSta strain, and when first received was growing in association with a single species of bacterium. Since a mixed bacterial flora gave more profuse growth, however, the culture was eventually maintained with a mixed unidentified bacterial flora for bioassays. Liver infusion agar (Difco) was used as a substrate, with either a Loeffler's-Ringer's or horse serum-saline overlay and a