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COMPARATIVE COCHLEAR RECONSTRUCTION IN MAMMALS

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The ratio between the size of the cochlea and that of the skull generally decreases when the skull size increases. In other words, the size of the cochlea in small mammals is considerably larger.

The number of cochlear turns increases when the cochlea protrudes into the well-pneumatized mastoid bulla instead of being embedded in the thick otic capsule.

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Makoto Igarashi and Toshiko Yoshinobu#

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U. S. NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

The size, length, and shape of the cochleas have been compared in different mammalian species, with the use of graphic cochlear reconstructions.

FINDINGS

The ratio between the size of the cochlea and that of the skull generally decreases when the skull size increases. In other words, the size of the cochlea in small mammals is considerably larger.

The number of cochlear turns increases when the cochlea protrudes into the well-pneumatized mastoid bulla instead of being embedded in the thick otic capsule.

ACKNOWLEDGMENT

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INTRODUCTION

Anatomical development of the cochlea progresses from the amphibian in which the initial form of the cochlea, macula basilaris, appears. Next in the progression are the cochlear duct (from the lagena), the perilymphatic ducts, and the organ of Corti (from the basilar macula); these are found in birds and crocodiles. The final stage is seen in mammals and appears as the cochlear spiral (1,6).

Cochlear spirals of mammalian ears are all of different sizes and shapes, and the basilar membrane of each varies in length. In addition, mammals have vastly differing skull sizes. The present study was designed to compare these anatomical aspects in various species.

PROCEDURE

Length of the basal membranes and the number of cochlear turns were measured in 17 human ears, 16 squirrel monkey (Saimiri sciureus) ears, 6 of the cat and rat, 4 of the guinea pig, 2 of the dog, and one each of the rabbit, kangaroo rat, and bat. All of these were adult inner ears. Only in the human, squirrel monkey, cat, guinea pig, and rat were the skull size and the diameter of the cochlea basal turn measured.

The temporal bones were fixed, decalcified, dehydrated, and embedded in celloidin. Those of the bat and rat were serially sectioned in horizontal plane at 16 microns, those of the guinea pig and kangaroo rat at 18 microns, and the remainder at 20 microns. One of each ten sections which were stained in hematoxylin-eosin made up a pilot set. Cochlea spirals were then graphically reconstructed according to the technique of Guild (2) and of Schuknecht (3).

Size of the skull was determined by measuring from the anterior edge of the frontal bone to the occipital point, long axis; and the distance between the two parietal bones at the widest point, short axis.

RESULTS

Average lengths of the basal membranes and the number of cochlear turns for each mammalian species examined are listed in Table I. Difference between the longest in length, that of the human, and the shortest (the bat and rat) was 24 mm. The basal membrane measurements of the other mammals fell in between. The number of cochlear turns of all species except the guinea pig and kangaroo rat was between 2-1/2 and 3.

A summary of the findings in the species whose skulls were measured is contained in Table II. From the measurement of the diameter of the cochlea basal turn, it can be seen that the size of the cochlea in the cat and in the squirrel monkey was approximately the same, yet the cat's skull was twice the size. In contrast, the skull of the guinea pig and rat was about the same size, but the cochlea of the former was larger and longer.

Table I

The Lengths of Basal Membranes and the Numbers of Cochlear Turns in Different Mammals

Species	The Average Lengths of Basal Membrane (mm)	The Number of Turns
Human	32	2 1/2 - 2 3/4
Dog	25	2 1/2 - 2 3/4
Squirrel Monkey	22	2 3/4 - 3
Cat	22	2 1/2 - 2 3/4
Guinea Pig	21	4
Rabbit	14	2 1/2
Kangaroo Rat	12	3 1/2 - 3 3/4
Rat	8	2 1/2
Bat	8	2 1/2

Table II

Summary of Findings in Five Different Species

Species	Skull Size (mm, long axis x short axis)	Diameter of Cochlea Basal Turn (mm)	Length, Basal Membrane (mm)	Turns in Cochlea
Human	180 x 135	6.2	32	2 1/2 - 2 3/4
Cat	70 x 40	3.8	22	2 1/2 - 2 3/4
Squirrel Monkey	47 x 35	3.7	22	2 3/4 - 3
Guinea Pig	35 x 22	2.3	21	3 3/4 - 4
Rat	30 x 17	1.2	8	2 1/4 - 2 1/2

Representative spiral reconstructions of the mammalian cochleas are shown in Figures 1-9. The arrow line at the top of each figure indicates the 1 mm scale to which the drawings were made. Inasmuch as these figures were drawn in the same scale, the ratio between each species demonstrates a comparison of the actual size of the cochleas.

DISCUSSION

The discussion of the present study will be limited to the comparative cochlear reconstructions. Since the cochlea is merely a part of the auditory system, it is critical to compare the auditory activities (including frequency range, discrimination, etc.) among the different species by comparing the cochlear structures. Obviously, there are many other factors, such as external and middle ear structures and functions, neural functions including cortical and efferent system functions, et cetera, which comprise the auditory function.

The lengths of the basal membrane in several mammalian species were measured by von Békésy and Rosenblith (4) who stated that the lower limit of hearing fell as the size of the animal increased, but the upper limit of resolution could not be determined because the vibratory amplitudes for the high frequencies were too small to measure. Thus, they observed no correlation between the lengths of the basal membrane and the hearing activity, especially in the frequency range.

With the method used in the present study (2,3) the cochleas were reconstructed from a three-dimensional structure to a two-dimensional plane by using horizontal serial sections, and the technical errors inherent in such a procedure should be considered. According to Schuknecht's method (3), the measuring error was less than 5 per cent on the average, and the error from the height of the cochlea (or the steepness of the basal membrane) was less than 3 per cent. Therefore, when spiral reconstructions are compared among the different species, the actual error in comparison is usually negligible.

The exact tangential section of the top of the Corti tunnel (contact of the tops of the inner and outer pillar cells) is not frequently seen on slides. Typical tangential cuts from the cat and the squirrel monkey are demonstrated in Figures 10-12.

In comparing the size of the skull with the size of the cochlea, it becomes obvious that the ratio is not so pronounced as it is between other parts of the body and the skull. For example, the difference in size between the body of a small animal as compared to a larger one is much greater than that between the cochleas of the same animals. The ratio between the size of a human skull and the squirrel monkey skull is more than 10:1; when the size of cochleas in the two are compared, the ratio drops to less than 3:1. The cochlea spiral of the elephant, according to von Békésy (4), is 60 mm in length, but its skull is tremendous in size.

The length of the basal membrane could not be related to the diameter of the basal turn of cochlea, or to the number of cochlear turns. There was only 1 mm difference between the length of the basal membrane of the squirrel monkey and that of the guinea pig. However, the diameter of the cochlear base was 1.4 mm larger in the former, and the cochlea of the latter had 3/4 to 1 more turn.

The cochlea of the guinea pig protrudes into the bulla while that of the other mammals was usually embedded in a thick, bony otic capsule. The kangaroo rat, which has about four cochlear turns, also has well-pneumatized mastoid bulla (5).

The length and shape of the cochlea hook area, which is a protruding vestibular cecum of the cochlear duct, vary to a large degree among different mammals. The human, cat, and guinea pig ears have a much longer formation of this structure than those of other mammals, and these three species have considerably long, well-developed cochlear spirals.

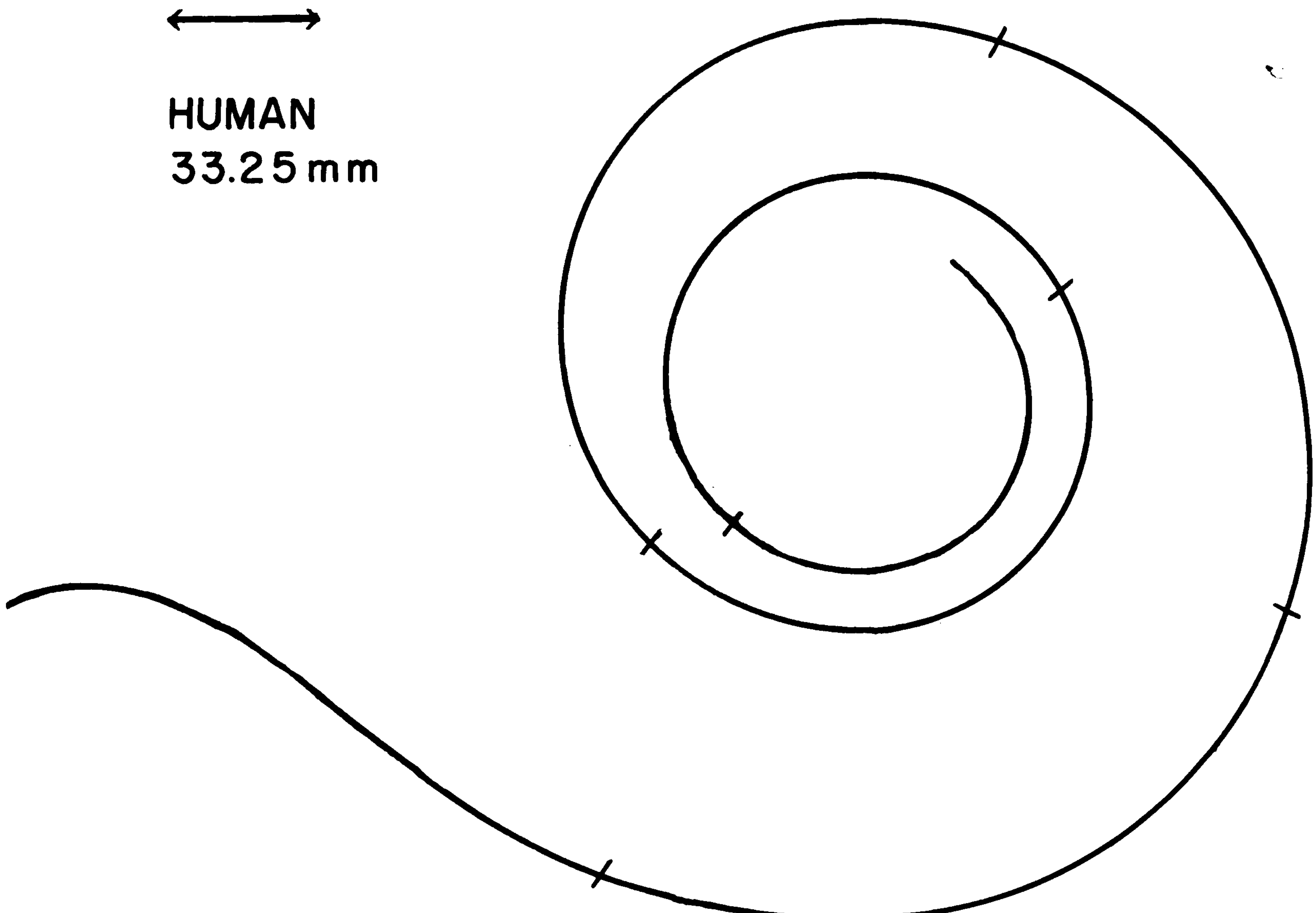


Figure 1

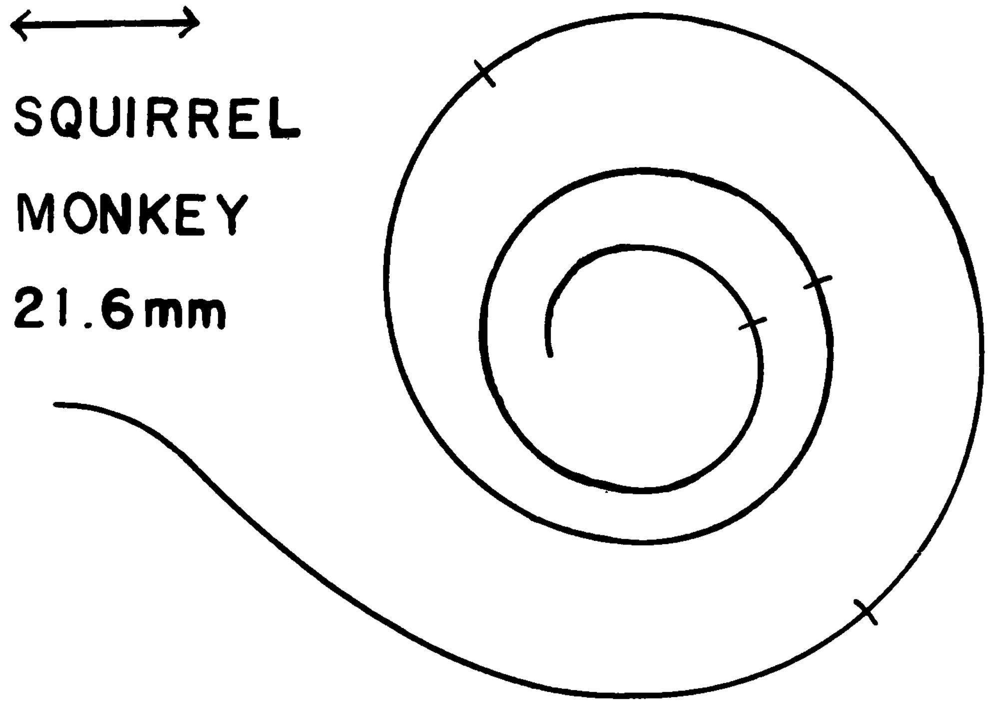
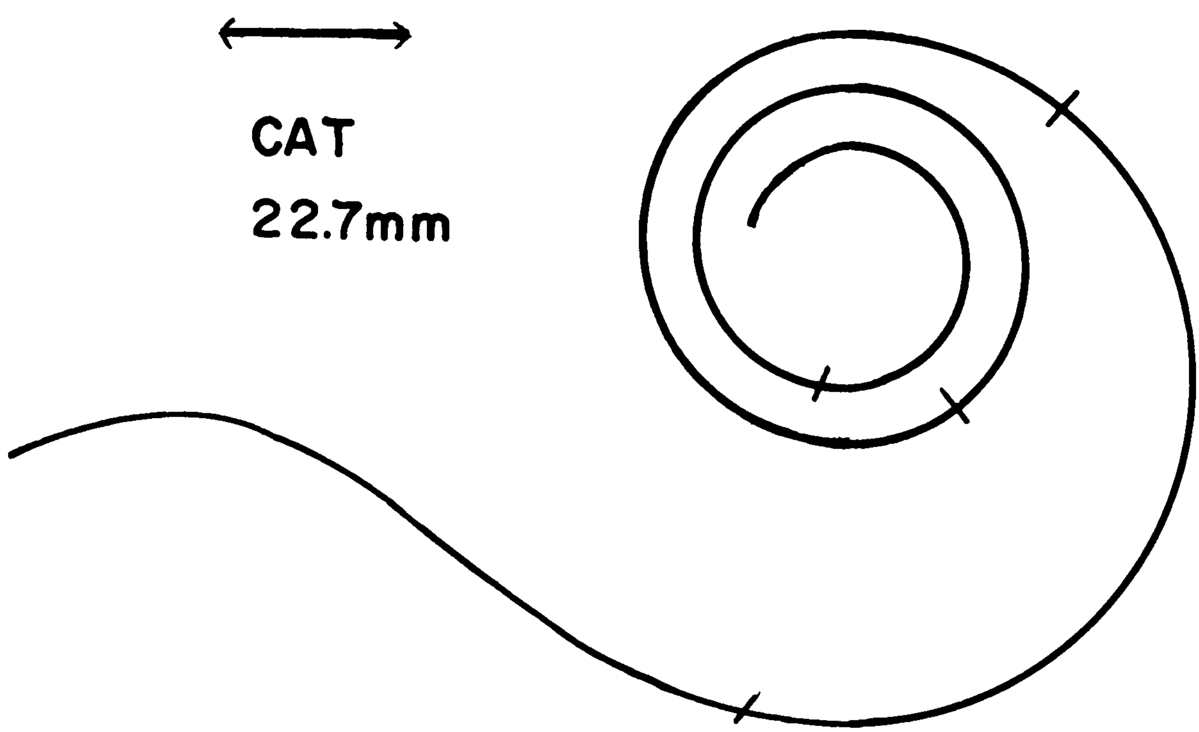


Figure 2



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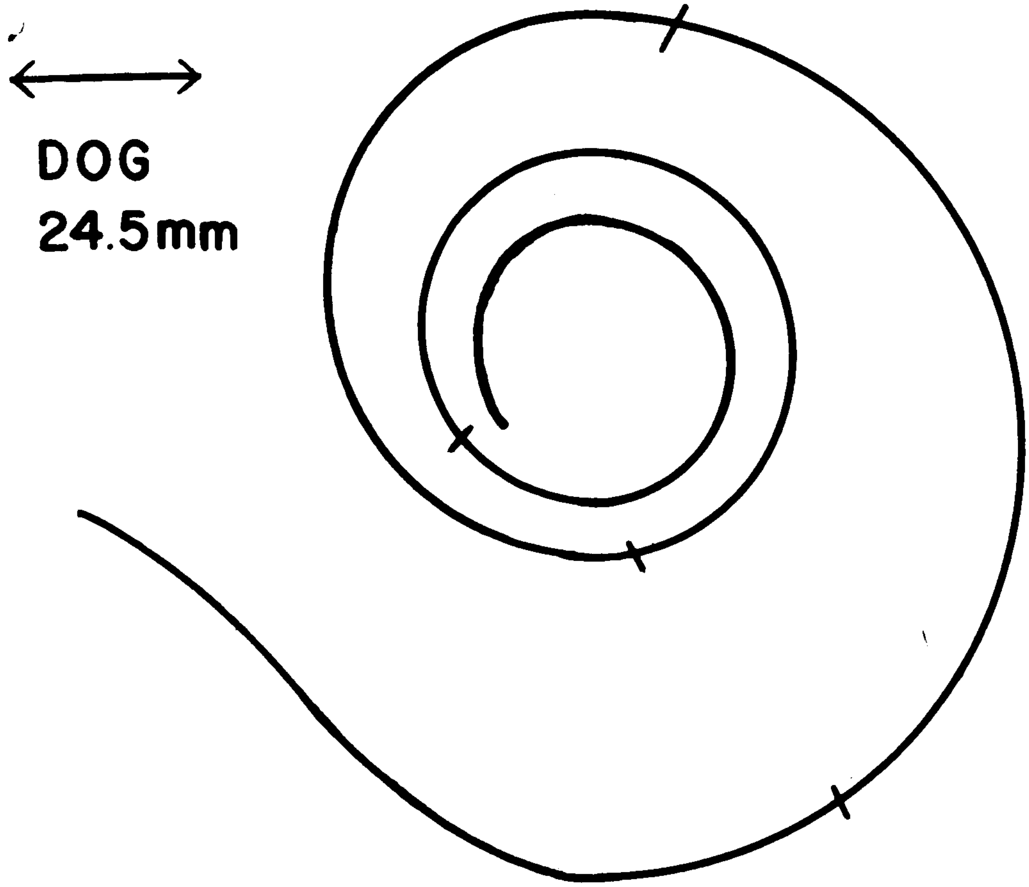

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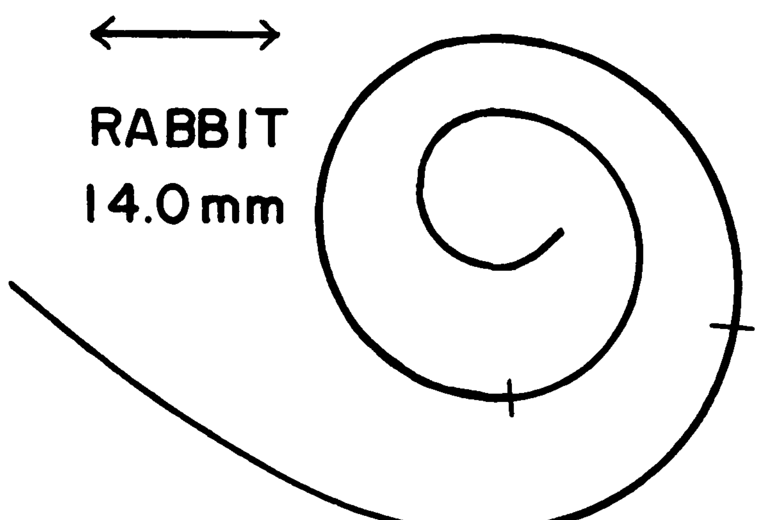

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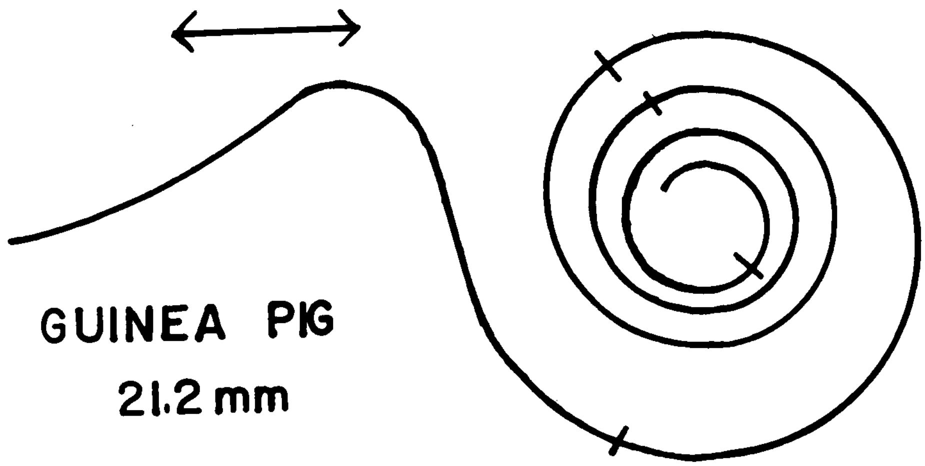

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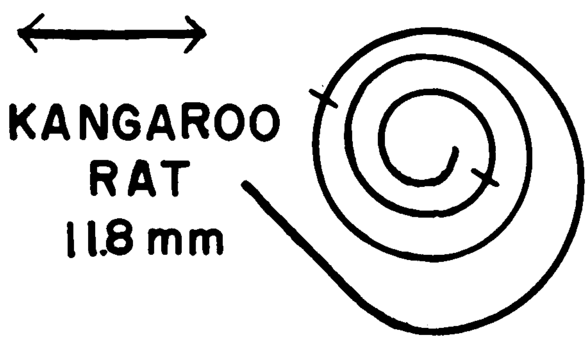

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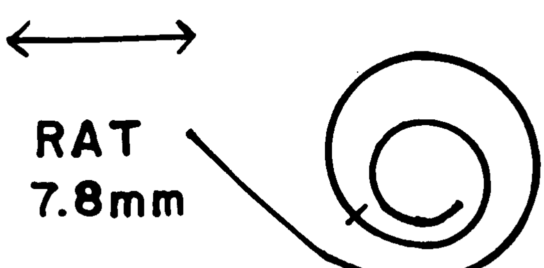

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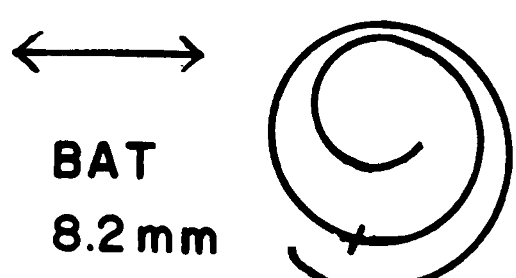

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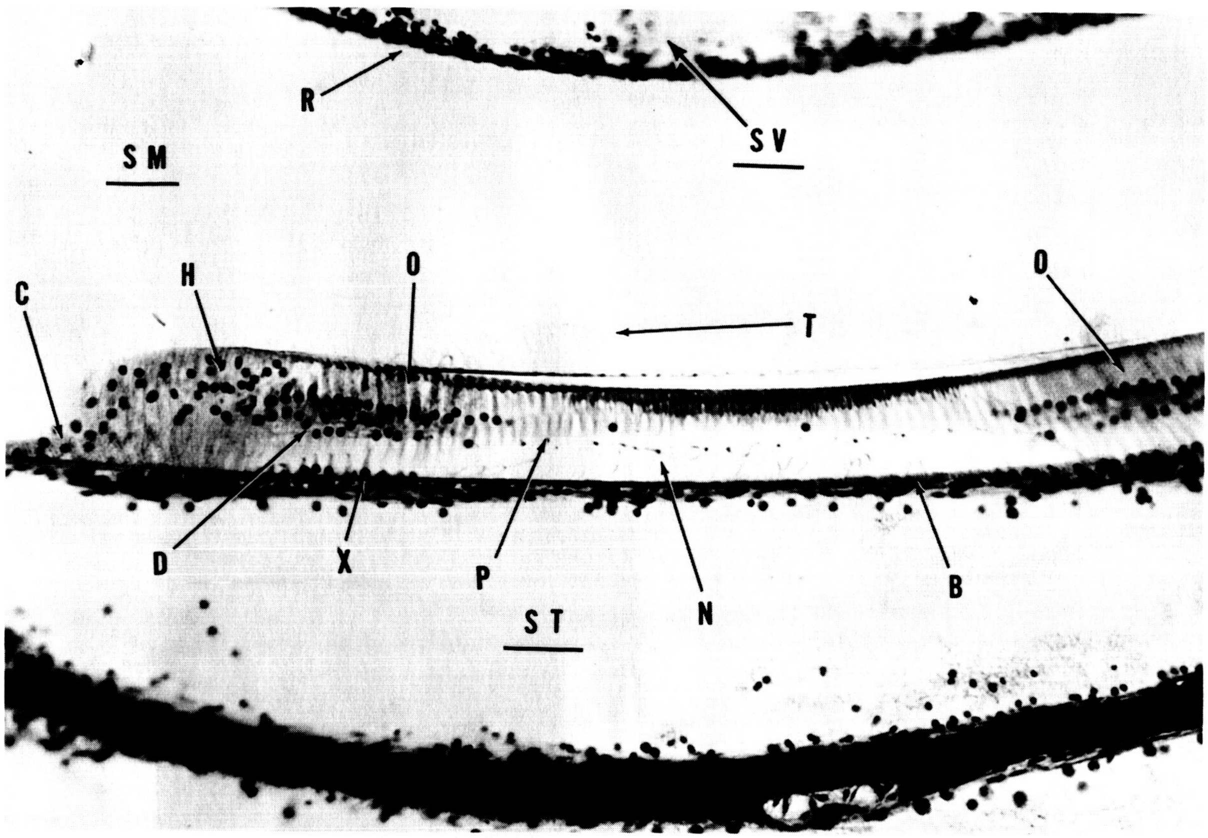

Figure 10

A typical tangential section of apical turn of cochlea (Squirrel Monkey). All important structures are labeled. 225X

SV - Scala Vestibuli
SM - Scala Media
ST - Scala Tympam
R - Reissner's Membrane
T - Tectoria
O - Outer Hair Cell
H - Hensen's Cell
C - Claudius' Cell
D - Deiter's Cell
X - Outer Pillar Cell
P - Outer Pillar
N - Tunnel Fiber (efferent)
B - Basal Membrane

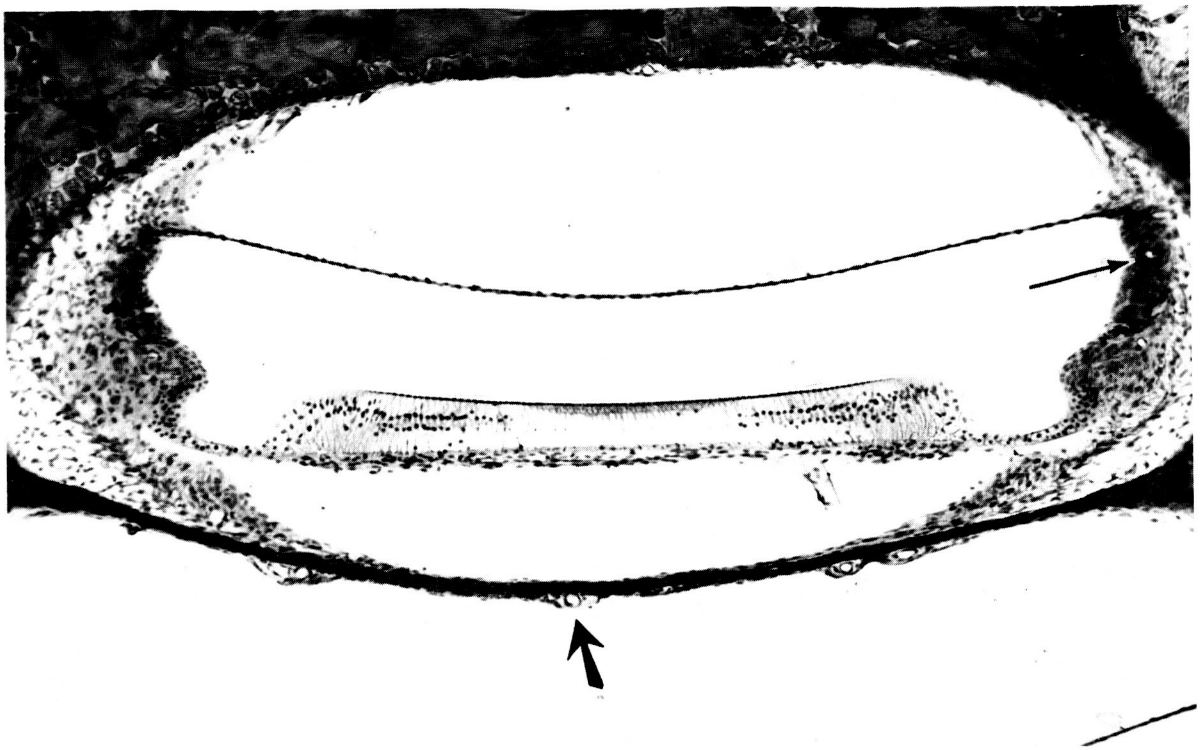

Figure 11

Another typical tangential section of apical turn of the Squirrel Monkey cochlea. 115X

When the animal is perfused successfully (intra-vital cardiac perfusion), all small vessels along the cochlea (large arrow), vessels in stria vascularis (small arrow), and vessels in spiral ligament become free from blood cells. This is an important sign of good fixation.

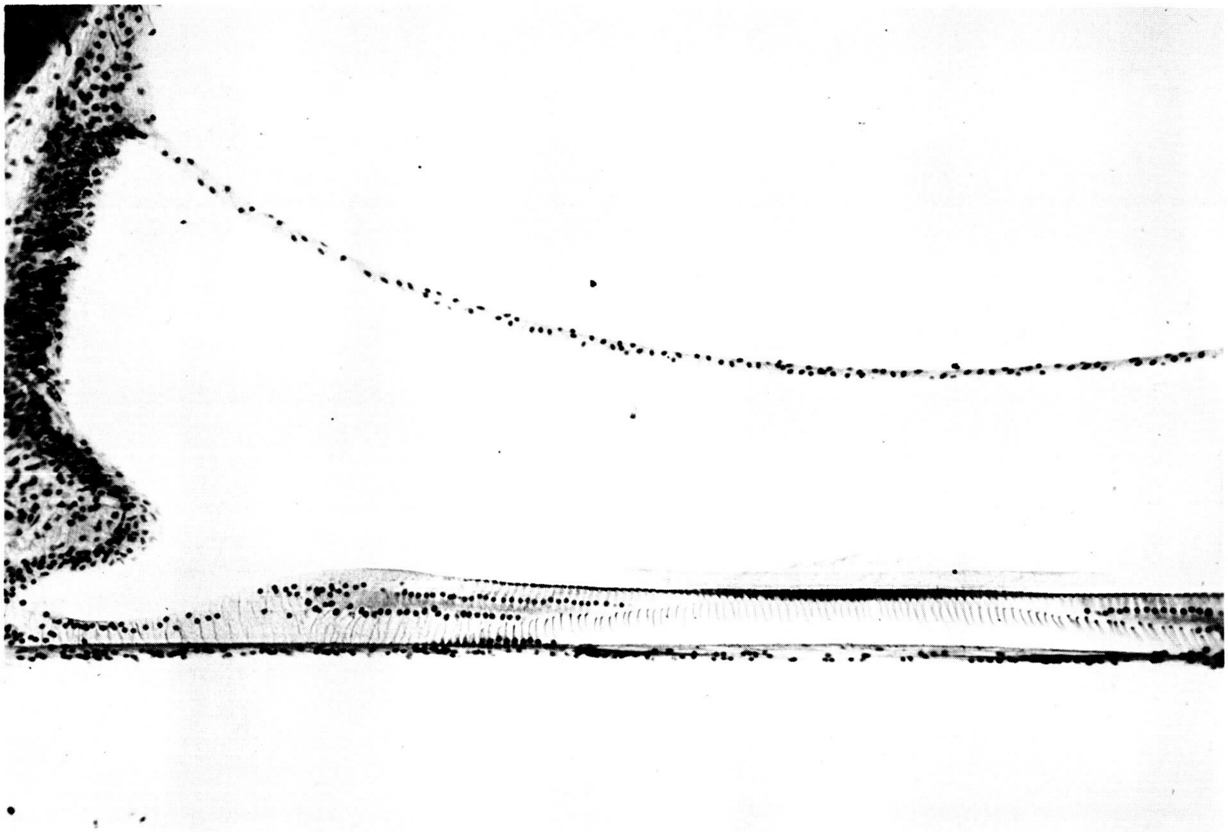

Figure 12

A typical tangential section of apical turn of the cochlea (cat). 150X

Note the artistic arrangement of end organ structures in cochlea. No post mortem change is seen.

REFERENCES

1. Brock, W., Phylogenese und vergleichende Anatomie des Gehoerorgans. In Denker, A. und Kahler, O. (herausgegeben), Handbuch der Hals-. Nasen-, Ohrenheilkunde. Berlin: Julius Springer, 1926. Pp 1-69.

2. Guild, S. R., A graphic reconstruction method for the study of the organ of Corti. Anat. Rec. 22:141-157, 1921.

3. Schuknecht, H. F., Techniques for study of cochlear function and pathology in experimental animals. Arch. Otolaryng.,58:377-397, 1953.

4. von Békésy, G., and Rosenblith, W. A., The mechanical properties of the ear. In Stevens, S. S. (Ed.), Handbook of Experimental Psychology. N. Y.: John Wiley & Sons, 1951. Pp. 1075 - 1115.

5. Webster, D. B., The ear apparatus of the kangaroo rat. Am. J. Anat.,108:123-128, 1961.

6. Werner, D. F., Das Gehoerorgan der Wirbeltiere und des Menschen. Leipzig: Veb Goerg Thieme, 1960.

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