The sense of hearing is fundamental in human life; hearing and speech together offer the most important means of communication among people, and are the basis of complex social interactions. It is not surprising, then, that loss of hearing can result in severe behavioral disturbance.

Men must have known since their early history that the ear is involved in the process of hearing. But it was not until the 17th century that the system of cavities buried in the mass of bone at the base of the skull was first suspected as the seat of audition. This system, the labyrinth, was eventually shown to be the organ of hearing, at the beginning of the 19th century. In the second half of that century a number of scientists turned their attention to the physiology of hearing and the problems of physical acoustics. The contributions of HELMHOLTZ are particularly notable, and his name is often heard even today. Nevertheless, many problems remained; some of them have been solved in this century, but many fundamental aspects of auditory physiology are still unclarified.

### 6.1 Anatomy of the Ear

An understanding of the physiology of audition requires some familiarity with the structure of the receptive apparatus. A brief review is given below, but this is not intended to be comprehensive. It is strongly suggested that the reader refers in addition to textbooks of anatomy.

The organ of hearing consists of the outer, middle, and inner ear (Fig 6–1). The meatus, the passage joining the first two of these, is closed at its inner end by the eardrum, or tympanum. This is thin membrane which has, in the healthy state, a mother-of-pearl sheen that provides the physician with a valuable diagnostic criterion. Behind the eardrum is the air-filled cavity of the middle ear. This space is connected to the pharynx (the throat) by a narrow passage called the Eustachian tube; when one swallows there is some exchange of air between throat and middle ear. Changes in external air pressure, like those experienced in air travel, cause an unpleasant feeling of “pressure in the ears”. This is due to stretching of the eardrum because of the pressure difference between the atmosphere and the middle-ear cavity. Swallowing, which opens the Eustachian tubes, permits equilibration of pressures on the two sides of the eardrum.
Fig. 6–1. Diagram of the outer, middle, and inner ear, greatly simplified. H, hammer; A, anvil; S, stirrup. The dashed outlines near H, A, and S show the extreme positions to which they can be driven as the eardrum oscillates.

There are three little bones, the ossicles, in the middle ear; these are called the hammer, anvil, and stirrup (or the Latin equivalents, malleus, incus, and stapes). They are connected flexibly so as to form a structure like a chain. One of the processes of the hammer is fused to the eardrum. When the eardrum is moved by vibration in the air it transmits this motion to the chain of ossicles. The stirrup actually does resemble a stirrup, with its foot plate set into an opening in the bone called the oval window. The foot plate of the stirrup marks the boundary between the middle ear cavity and the third part of the auditory organ, the inner ear. The ossicular chain thus forms a bridge from eardrum to oval window — from the air to the inner ear. It is over this path that sound energy reaches the inner ear, which (as we shall now see) houses the sensory cells.

The inner ear lies within the temporal bone; it is in direct communication with the organ of equilibrium (cf. Fig. 6–1). The two organs together are called the labyrinth. Because of its shape, the inner ear is also called the cochlea (from the Latin for “snail” — it is shown partially uncurled in the drawing). We shall return to the equilibrium organ in the next chapter. The cochlea comprises three tubular canals running parallel to one another; these are coiled together to form a helical structure. Figure 6–2 shows a section through the axis of the helix, so that the canals wound around it are cut at several places. These canals are called the scala vestibuli, scala media or cochlear duct, and scala tympani. The human cochlea has about two and a half such helical turns. Its general arrangement can be seen in Figure 6–1; this simplified drawing shows only ca. one turn of the helix. The foot plate of the stapes at the oval window adjoins the scala vestibuli, which is filled (like the other canals) with fluid. Scala vestibuli and scala tympani contain the so-called perilymph, whereas the cochlear duct contains endolymph. The two fluids