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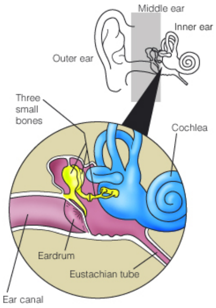

By: Vlad Tarko, Senior Editor, Sci-Tech News

Did Our Ancestors Breathe through Their Ears?

A fossil fish skull from Latvia seems to indicate so

Evolution works in mysterious ways. And among the most fascinating ones is how it changes its "mind", how some things get developed for a certain function and at some point they are "stolen" by some other function. This is what researchers at Uppsala University, Sweden, have now discovered about the evolution of hearing."It looks as if the first step in the evolution of the middle ear had nothing to do with hearing. Our forebears developed ears in order to breathe through them," says Professor Per Ahlberg. The human sense of hearing is based on the interaction of two different organs: the inner ear and the middle ear. The inner ear performs a preliminary sound analysis, separating the sound into frequencies, and contains sensory cells that capture sound vibrations and send them on as nerve impulses to the brain. The middle ear is a mechanical audio amplifier that captures the weak sound vibrations in the air with a membrane (the eardrum), amplifies them (with the help of the ear bones) and sends them on to the inner ear. Without the middle ear, the inner ear would not function. All vertebrates have inner ears, but only land animals have middle ears. Fish don't need middle ears since sound vibrations are stronger in water. However, the construction of the middle ear differs among different groups of land animals: while mammals have an eardrum and three ear bones (hammer (malleus), anvil (incus), and stirrup (stapes)), birds, reptiles, and frogs have only one ear bone (stirrup) that connects the eardrum directly to the inner ear. It is also questionable whether the eardrums in mammals, reptiles, and frogs are identical or whether they arose independently of each other. All these animals have **evolved from fish**. Thus, scientists were curious how the middle ear evolved. It was found that instead of middle ears, fish have a little gill, the blow-hole, that isn't covered by an eardrum but rather forms an open canal between the throat and the outside of the head. The equivalent of the stirrup, the hyomandibula, supports the gill lid but has no contact with the inner ear. Neither the hyomandibula nor the blow-hole plays any role in hearing. These differences make it difficult to understand how the middle ear arose. How could evolution change both the structure and function of the fishes' blow-hole so radically? Did the earliest land animals have a sound amplifying middle ear at all? The earliest fossil land vertebrates or tetrapods, like Acanthostega from Greenland (that lived roughly 360 million years ago), depicted in the picture below, had a stirrup that was in contact with the inner ear, but it was large and clumsy and appears not to have been connected to the eardrum. They also had a couple of round outlets, in the rear edge of the skull: in modern frogs the corresponding outlet is the binding point for the eardrum, but in fish it is the site of the outer opening of the blow-hole. This combination of characteristics suggests that the earliest land animals still had open blow-holes and perhaps breathed through them.The Uppsala scientists found new data that strongly support this hypothesis. They studied the skull of a Panderichthys from Latvia, a fossil fish that is closest to the emergence of land animals. It has been known that Panderichthys had a hyomandibula, and it was generally assumed that its blow-hole was of the normal fish type. However, in fact the hole is similar to the middle ear, of a tetrapod like Acanthostega. Since the hyomandibula of the Panderichthys had no contact with the inner ear, its blow-hole could hardly have had a sound-amplification function. "Thus the transformation of the form of the blow-hole must have been caused by another driving force than the improvement of hearing," says Per Ahlberg. Compared with closely related fish, the blow-hole in Panderichthys has a considerably larger diameter and is furthermore both shorter and straighter. It looks like an adaptation to active breathing (of either water or air) through the blow-hole, compared to ordinary fish in which only a small portion of breathing water passes through this hole. The middle ear in the earliest tetrapods has the same form as the blow-hole in Panderichthys and it retained the breathing function. But in tetrapods the gill lid is gone and the hyomandibula is transformed into a primitive stirrup. Thus, what happened was that the blow-hole got larger and larger helping the animal breath easier, but in this process the hyomandibula/ primitive stirrup got closer to the inner ear. When it came into contact with the inner ear it also helped improve hearing. Later on, the middle ear became more and more important for the hearing function and less and less important for the breathing function."We can speculate about how this came about. The blow-hole of a fish can be closed by a valve muscle on top. If an early tetrapod did the same thing, a truly enclosed middle ear was temporarily created, where the stirrup, which probably supported the wall of the middle ear, could forward vibrations from the middle ear to the inner ear. When the hearing function eventually became more important, the blow-hole was permanently closed by an eardrum," reasons Per Ahlberg. It is interesting that our auditory system still has a left over from the time when the middle ear served a breathing function. The middle ear is connected to the pharynx thru the Eustachian tube. This tube now serves mainly a pressure equalization function, maintaining (roughly) the same pressure inside the middle ear as it is in the outside world.