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Contributions of the anatomist Emil Huschke to otorhinolaryngology

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Abstract:

When studying the history of biology and its relation to modern otorhinolaryngology the life work of Emil Huschke (1797-1858), a developmental biologist who mainly worked in Jena, Germany, has to be appreciated. His comparative anatomical studies, in the period between the speculative natural philosophy of his teacher Lorenz Oken (1779-1851) and the upcoming measuring and analytical science, focus on embryology and anatomy of several organs in the field of otorhinolaryngology. Years after Huschke's birth there are still some anatomical structures which are connected with his name such as Huschke's auditory teeth in the inner ear (original German term: "Gehörzähne"), Huschke's foramen in the external auditory meatus, or Huschke's valve at the beginning of the lacrimal duct. This present brief history will summarize Huschke's contributions to the development of otorhinolaryngology. Most of the cited original German references were translated into English by the authors.

His early life and student days

Emil Huschke was born in Weimar, Germany, as the second son of the court physician ("Hofmedikus") Wilhelm Christian Huschke and his fourteen years younger wife Christiane. In Weimar Emil Huschke attended the high school ("Gymnasium") and studied medicine at the University of Jena from 1814 to 1818. In the awakening after the wars of liberation he became a member of the early national students' associations which were founded in Jena. In 1817 he took part in the first Wartburg festival, where students and professors for the first time officially requisitioned the overcoming of German sectionalism.

His academic career

In 1818 he published his doctoral thesis ("inaugural dissertation") about the development of the respiratory organs and the air-bladder in fishes (Fig. 1). In a review it was praised as 'remarkable' (Fig. 2). After travels to Berlin, Vienna, and South Germany he qualified as a professor in Jena in 1821 and became a private lecturer ("Privatdozent"). He had the opportunity to present the results


DISSERTATIO INAUGURALIS MEDICA
QUAEDAM
DE ORGANORUM RESPIRATORIORUM
IN ANIMALIUM SERIE
METAMORPHOSI GENERATIM SCRIPTA
ET DE
VESICA NATATORIA PISCIUM
QUAESTIONEM.

QUAM
RECTORE ACADEMIAE MAGNIFICENTISSIMO
AUGUSTO ET POTENTISSIMO PRINCIPE AC DOMINO
DOMINO
CAROLO AUGUSTO
[illegible]
CONSENTIENTE
GRATIOSO MEDICORUM ORDINIS
PRO GRADU DOCTORIS
IN MEDICINA ET CHIRURGIA HONORIBUS
IURIBUS ET PRIVILEGIIS
RITE CONSEQUENDIS
A. D. XII. MARTII CIↃIↃCCCXVIII.
EXHIBUIT
AUCTOR
AEMILIUS HUSCHKE
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Fig. 1. Cover page of the doctoral thesis of Emil Huschke 1818 [36].

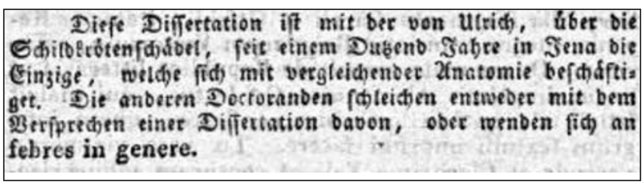
Diese Dissertation ist mit der von Ulrich, über die Schildkrötenschädel, seit einem Dutzend Jahre in Jena die Einzige, welche sich mit vergleichender Anatomie beschäftiget. Die anderen Doctoranden schleichen entweder mit dem Versprechen einer Dissertation davon, oder wenden sich an febres in genere.

Fig. 2. Extract from a review of Huschke's thesis, (ISIS X, 1818, p. 1638): "Since the publication of Ulrich's thesis about the skull of turtles, this thesis is the first in the last dozen years in Jena dealing with comparative anatomy. Other doctoral candidates sneak away with the promise to write a thesis, or escape with lame excuses."

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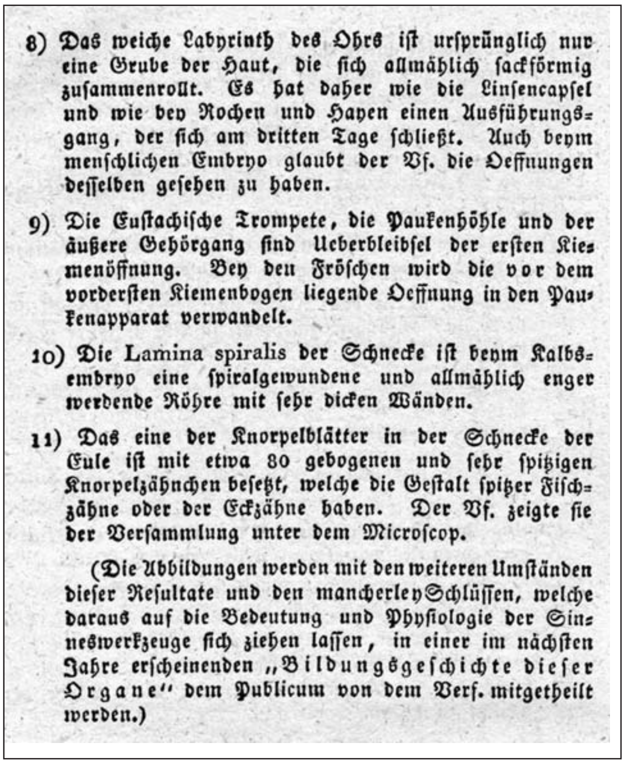
of his research at meetings of German Naturalists and Physicians, a German scientific association founded in 1822 in Leipzig. In 1838 he was appointed full professor of anatomy and physiology at the medical faculty of the University of Jena. He was nominated in Breslau as a member of the Leopoldina in 1849.

After the retirement of the anatomist Johann Friedrich Fuchs (1774 - 1828), Johann Wolfgang von Goethe, who was at the court of Weimar and also responsible for the University of Jena, entrusted Huschke with the supervision of the anatomical museum. Following the anatomists Ferdinand Justus Christian Loder (1753-1832), Jacob Fidelis Ackermann (1766 -1815) und Johann Friedrich Fuchs (1774 -1828), Huschke was the fourth anatomist to maintain close contact with Goethe [1].

Fig. 3. Gravestone of the family tomb of the Huschke family, Johannisfriedhof, Jena, Germany (author`s image).

Private life and death

Huschke married the twelve year younger Emma Rostosky in 1830. They brought up six children. Huschke's youngest daughter Agnes (1842-1915) became the second wife of Ernst Haeckel (1834-1919). Emil Huschke never personally met the famous zoologist Haeckel. In June 19th 1858, Emil Huschke died from an inflammation of the brain. Until today the common gravestone of the Huschke family can be visited in an old cemetery, the "Johannisfriedhof" in Jena (Fig. 3). Memorial plaques at and in the building of the Anatomy of the University of Jena reminds us of this eminent scholar of the 19th century.



8) Das weiche Labyrinth des Ohrs ist ursprünglich nur eine Grube der Haut, die sich allmählich sackförmig zusammenrollt. Es hat daher wie die Linsencapsel und wie bey Rochen und Hayen einen Ausführungsgang, der sich am dritten Tage schließt. Auch beym menschlichen Embryo glaubt der Vf. die Oeffnungen desselben gesehen zu haben.

9) Die Eustachische Trompete, die Paukenhöhle und der äußere Gehörgang sind Ueberbleibsel der ersten Kiemenöffnung. Bey den Fröschen wird die vor dem vordersten Kiemenbogen liegende Oeffnung in den Paukenapparat verwandelt.

10) Die Lamina spiralis der Schnecke ist beym Kalbsembryo eine spiralgewundene und allmählich enger werdende Röhre mit sehr dicken Wänden.

11) Das eine der Knorpelblätter in der Schnecke der Eule ist mit etwa 80 gebogenen und sehr spitzigen Knorpelzähnchen besetzt, welche die Gestalt spitzer Fischzähne oder der Eckzähne haben. Der Vf. zeigte sie der Versammlung unter dem Microscop.

(Die Abbildungen werden mit den weiteren Umständen dieser Resultate und den mancherley Schlüssen, welche daraus auf die Bedeutung und Physiologie der Sinneswerkzeuge sich ziehen lassen, in einer im nächsten Jahre erscheinenden „Bildungsgeschichte dieser Organe" dem Publicum von dem Verf. mitgetheilt werden.)

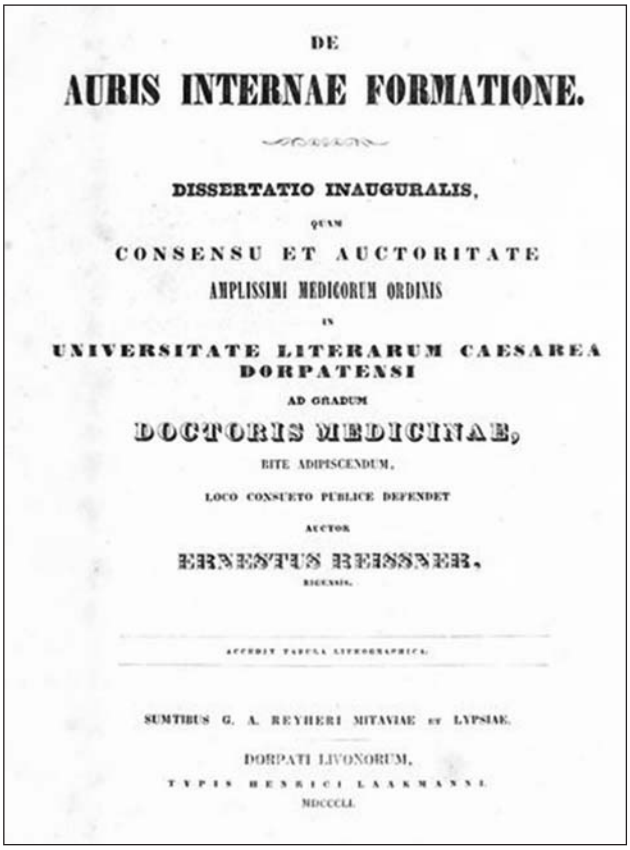
Fig. 4. Extract from Huschke's lecture in Hamburg, Germany, 1830, (ISIS 1831, S. 950-951).

The membranous labyrinth

Huschke was probably the first embryologist to recognize that the membranous inner ear originated from ectoderm [2]. Already in 1824 he stated that the labyrinth is a product of ectoderm like the outer skin. At the same time, he revealed that the tympanic cavity and the Eustachian tube are continuations of the entoderm like the main parts of the intestinal tract [3]. In the embryo of the hen he described a bilateral epithelial thickening on the back surface of the region of the hind brain. Here the external germ layer circularly thickens to form the hearing placode which begins to invaginate to form the otic pit and finally the otocyst under the regenerated epithelium. The membranous labyrinth is developed from the otocyst (Fig.4, p.172) [2,4]. Consequently, as Huschke discovered, the membranous labyrinth originates independently from the brain. Later the cochlear and vestibular ganglion cells develop from the epithelium of the otocyst and gain contact to the brain in form of the auditory nerve. Although nerve fibers can be demonstrated early in the inner ear and the organ of Corti is differentiated by the 6thmonth, the human embryo is usually not able to hear before the 30th gestation week [2].

By investigating embryos of sheep and calves Huschke, in 1830, found that the spiral lamina of the inner ear is hollow [4]. He falsely supposed that the scala vestibuli and scala tympani compress the spiral tube during the ontogenetic course and thus form the spiral lamina. He did not recognize the importance of the hollow structure for the function of hearing and thus did not find the cochlear duct [5]. This honor is given to Ernst Reissner (1824 -1878) who discovered that the spiral tube that was described by Huschke in the embryo is persistent in the adult as cochlear duct. Together with Karl Bogislaus Reichert (1811-1883) Reissner discovered that the membranous part of the spiral lamina and a very thin epithelial membrane, Reissner's membrane, respectively form the boundary of the three-cornered cochlear duct, the "Schneckenkanal" (Fig. 5) [6]. Albert von Kölliker (1817-1905) named it the 'Scala media' [7] in 1879 and stated: "The embryonic "Schneckenkanal" is not at all a transient structure as in his time Huschke still believed, but turns into the middle canal of the cochlea discovered by Reissner in the adult, which this author named canalis cochlearis. The term scala media I gave up later to prevent people from believing that the scala media and the scala tympani and vestibuli take the same course of development".

In his Handbook of Physiology of the Sensory Organs ("Handbuch der Physiologie der Sinnesorgane") [8] Hensen in 1880 called attention to the fact that Huschke had already in 1824 suspected in his comparative anatomical studies connecting canals between the labyrinth and intracranial structures [3]. It was Weber-Liel (1832-1891)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AURIS INTERNAE FORMATIONE.
DISSERTATIO INAUGURALIS,
QUAM
CONSENSU ET AUCTORITATE
AMPLISSIMI MEDICORUM ORDINIS
IN
UNIVERSITATE LITERARUM CAESAREA DORPATENSI
AD GRADUM
DOCTORIS MEDICINAE,
RITE ADIPISCENDUM,
LOCO CONSUETO PUBLICE DEFENDET
AUCTOR
ERNESTUS REISSNER,
SUMTIBUS G. A. REYHERI MITAVIAE ET LYPSIAE.
DORPATI LIVONORUM,
TYPIS HENRICI LAAKMANNI.
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Fig. 5. Doctoral thesis of Ernst Reissner, 1851, at the university of Dorpat [6].

in 1879 who proved that the aquaeductus endolymphaticus is passable and that the aquaeductus endolymphaticus as well as the aquaeductus perilymphaticus are communication roads between the intracranial space and the labyrinth. (Fig. 6) [9]. At that time it was already known that pressure changes in the labyrinth can be equalized via both aquaeducti. As a consequence, the exploration and drainage of the endolymphatic sac to release the endolymphatic hydrops in patients with Menière's disease was introduced [10]. The

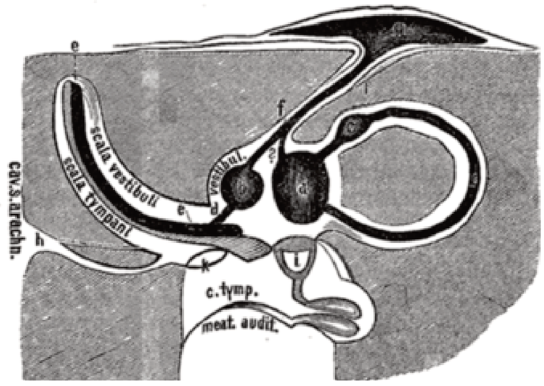

Fig. 6. Scheme of the labyrinth by Weber-Liel, 1879 [9].

discovery of the communication between these systems also explained another disease related to the aquaeducti: the 'Gusher' phenomenon. Here, the patients have a congenital or post-traumatic expanded connection between the perilymphatic space and the cerebrospinal fluid spaces. The pressure of the cerebrospinal fluid thereby hinders the normal movement of the stapes. This results in a combined low frequency hearing loss as in otosclerosis. When the oval window is then perforated during stapes surgery, the cerebrospinal fluid suddenly surges out into the middle ear [11]. To this day one can see in the Museum Anatomicum Jenense a skull of a two years old child with a hydrocephalus from the classical time when Huschke was the head of that museum (Fig. 7, p.175). For the otologist Huschke's best known discovery are the auditory teeth ("Gehörzähne") later named after him [12]. Following his comparative anatomical examinations in birds these teeth originate from the trabeculae of the lamina spiralis of the cochlear bulb ("Schneckenkolben"; Fig. 8). In the cochlea of mammals the teeth in the inner ear can be found in the area of the labium vestibuli, i.e. the phylogenetically higher developed lamina spiralis. Huschke did not have any hypothesis on the function of these teeth. He wrote in 1835 [12]: "The specific function of these parts will be kept hidden until vivisection and acoustics will provide additional information on the mechanisms of hearing and especially of the labyrinth. What we can now conclude on the function of parts of the labyrinth, is limited to the capacity to guide, concentrate and refine the acoustic radiation. This knowledge is very superficial and hence insufficient. All other statements are at present made up out of thin air." Probably Huschke was the first to see the relation between the papilla basilaris, the origin of the Corti organ, and the hearing function. He observed that the scala tympani and the scala vestibuli separated the lamina spiralis from the bony walls of the cochlea, somehow being free-floating in the perilymph. Therefore, it seemed unlikely for him that "the cochlea is able to sense the waves coming from the cranial bones to the ear", as he speculated in 1844[13]. The auditory teeth that appeared

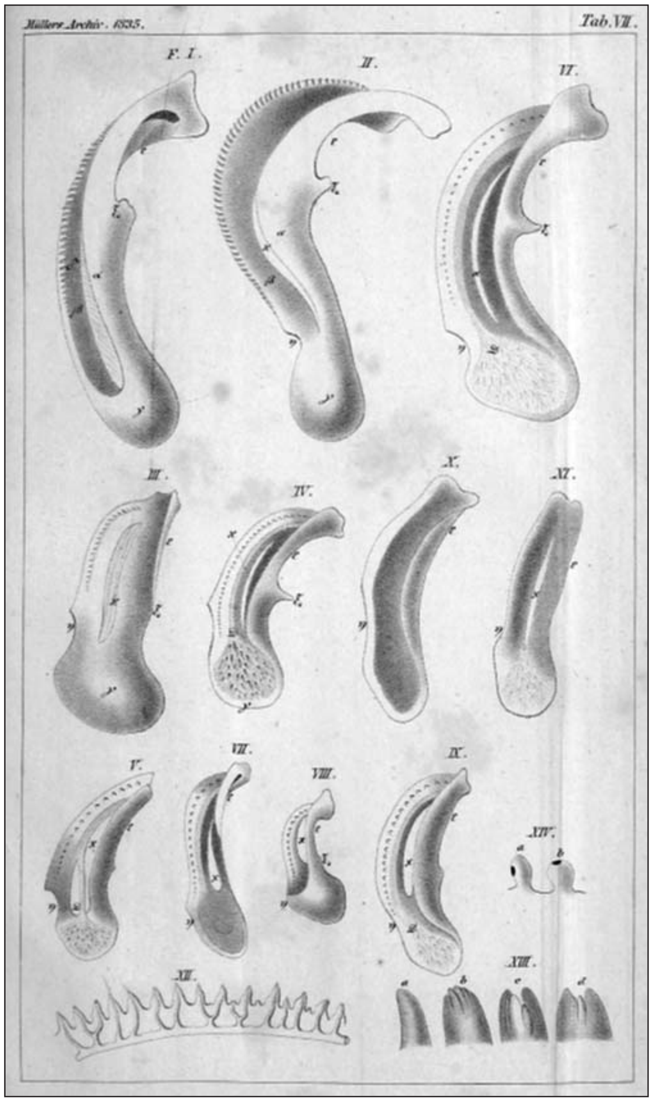

Fig. 8. Huschke's auditory teeth in birds adapted from [12]: (F)igure I =left cochlear cartilage with auditory teeth from an owl (7 fold); III = mouse falcon (7fold), IV = raven (7 fold); V= swallow (7 fold); VI = sparrow (20 fold), VII = pigeon (7 fold); VIII = plover (7 fold); IX = snipe (7 fold); X = goose (7 fold); XI = great crested grebe(7 fold); XII = parts of the auditory teeth in owls with blood vessels (30 fold).XIII a, b, c, d = different forms of teeth in robins (magnification unclear); XIV = two teeth of the common raven (magnification unclear).

like incisors, radial strip-like structures, were strung on the crista spiralis. Many later anatomists investigated these teeth because of their fascinating microscopical appearance. Hensen (1835-1924) noted in 1880 that the tectorial membrane was strongly attached medial to Huschke's auditory teeth but was without real outer attachment [8]. Retzius (1842-1919) calculated that the human cochlea should contain about 2500 of Huschke's teeth [14]. Henle determined the length of an auditory tooth with 30 μm and 10 μm for the wart-like elevation (cited in

Fig. 7. Skull of a two years old child. Large fontanelle not yet closed (hydrocephalus "Hirnwassersucht?" Huschke). Sutura frontalis with its upper end shifted by 1/3 inch from Sutura sagittalis to the right. Strongly protruding tubera parietalia (Huschke, p.30, no. 7), image from Museum Anatomicum Jenense

[15]). Today, we consider that the interdental cells lying in the grooves between Huschke's auditory teeth are producing glycoproteins for the overlying tectorial membrane (Fig. 9-10) [16-18].

The bony labyrinth and bony parts of the middle ear

Huschke was also interested in the evolution of the ossicles. He discovered first in birds and later in calves and human embryos that "the ossicles do not develop as independent bones but to serve hearing are distorted parts of the ribs, partly of the mandible, partly derived from the second branchial arch in mammals and birds" [19]. The malleus and incus were derived from the first branchial arch. The dorsal parts of the second branchial arch, the branchial cartilages (Reichert's cartilage) form in the middle ear the stapes and the processus styloideus ossis temporalis [8]. The middle part of this cartilage, lying between the styloid process and the hyoid bone, degenerates during development. Its perichondrium builds a stylohyoid ligament. The anterior ventral of Reichert's cartilage builds the cornu minus ossis hyoidei and also the superior part of the hyoid bone. Huschke discovered that the still cartilaginous upper part of the cornu major ossis hyoidei is transferred into the styloid in an early embryonal phase. The early styloid itself get into connection with the crus breve of the incus [19].

The foramen of Huschke, also named foramen acusticum Huschkei or foramen tympanicum, is a rare inhibition of

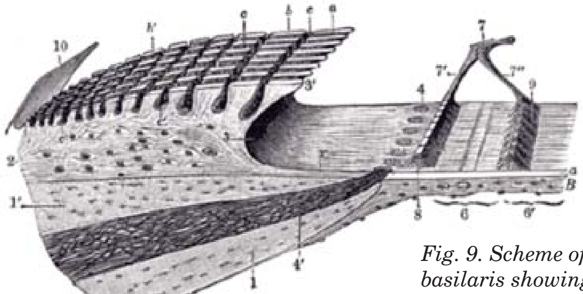

Fig. 9. Scheme of the limbus laminae spiralis and the membrana basilaris showing Huschke's auditory teeth, adapted from Gray [37]: 1,1' = upper and lower lamella of the lamina spiralis ossea; 2 = limbus lamina spiralis with auditory teeth (a, b, b'); 3 = Sulcus spiralis internus; 4´ = ganglion spiral; 6 = basilar membrane; 7, 7', 7'', 4 = Corti's spiral organ; 10 = part of Reissner`s membrane .

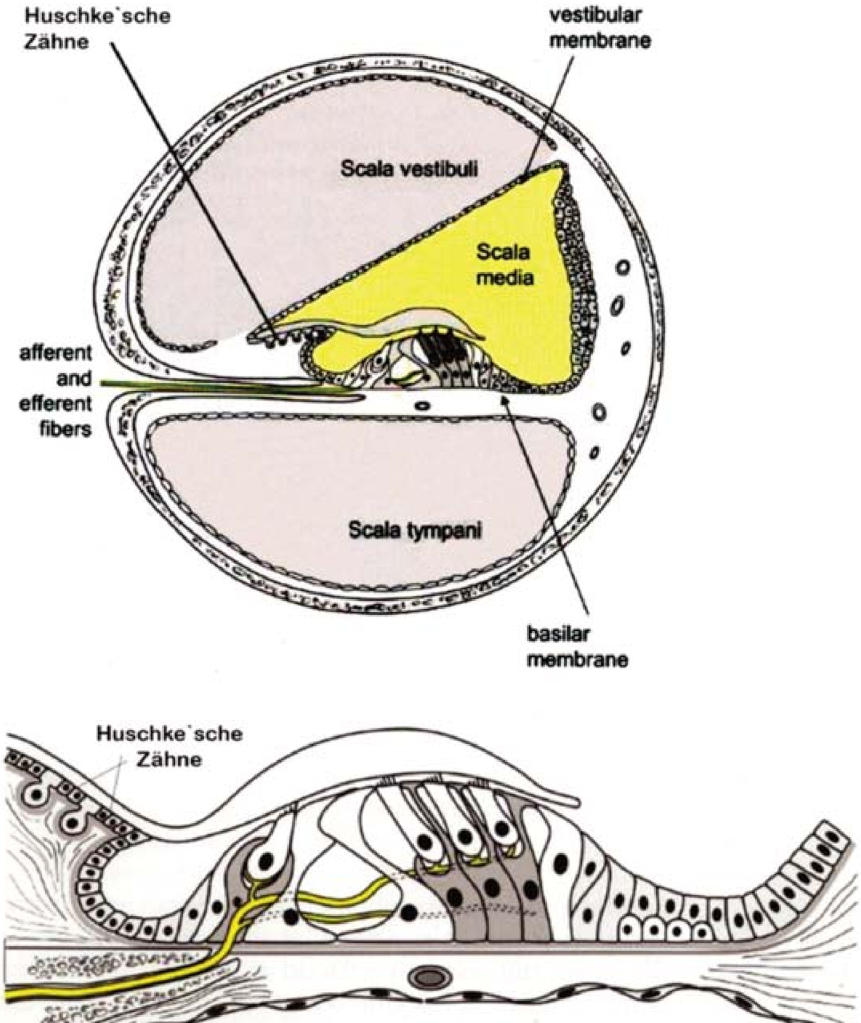

Fig. 10. Cross section through the human cochlea (above), and in higher magnification (below): Basilar membrane with the Corti organ und Huschke's auditory teeth. Permission by the author and adapted after Paxinos, Fig. 36.2, Copyright 2000 National Academy of Sciences, [18].

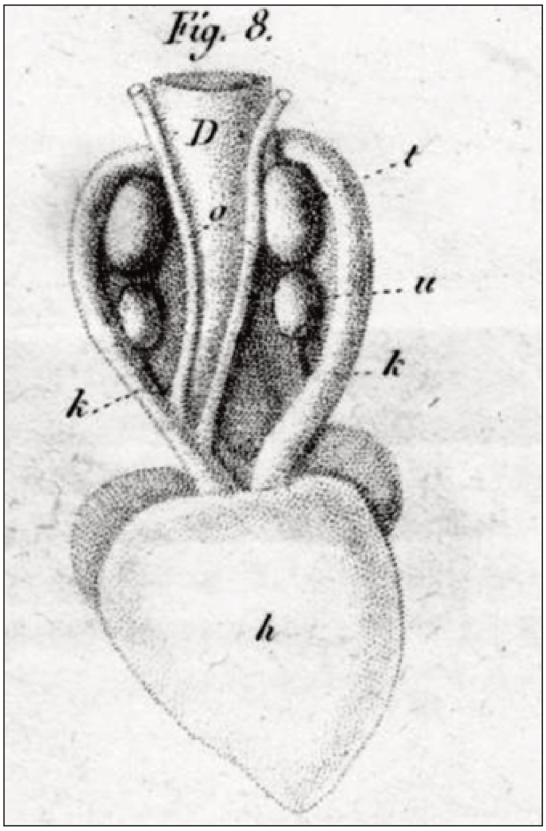

Fig. 11. Eighth day of a bird embryo. - Frontal view of the heart and esophagus. The branchial arches have already disappeared, and 2 primordia of thyroid gland are developed between the Art. branch. I. (anonyma) and II (Aorta and Art. pulmon. sinistra) [38].

ossification at the anterior-interior wall of the bony outer ear canal. Huschke, who in 1844 named this embryonic remnant the incisura Santorini, was probably not the first anatomist to describe this remnant [13]. It was the famous German otologist Anton Friedrich von Tröltsch (1829-1890) who associated this defect at the outer ear canal with the name of Huschke. Von Tröltsch discovered (differently from Huschke) that adults may also present with small gaps in the anterior wall of the outer ear canal. Von Tröltsch in 1860 drew attention that "these gaps or thinned out part" may be related to pathological processes in the area of the outer ear canal [20] such as the unusual phenomena of a spontaneous gustatory otosialorrhea [21-25], herniation of soft tissue from outside the outer ear canal [26], or the extension of an ear infection on the parotid gland or on the mandibular joint [27]. The exciting, informative, scientific but also historico-cultural work from 2015 "Huschke's anterior external auditory canal foramen: art before medicine?" showed that the foramen of Huschke was first presented in performing art by Marinus van Reymerswaele in the first half of the 16th century [28].

Thyroid and parathyroid

Huschke believed that the thyroid gland develops from gills: he found analogies of the thyroid in tadpoles and in the brown grass frog. He also believed that the superior and inferior thyroid artery as well as the thyreoidea ima artery (feared in case of tracheotomy) were remnants of the arteries of the gills. When he performed comparative anatomical studies (Fig. 11), he observed that a thyroid gland first appeared in amphibians and that the two thyroid lobes only sit close together to form one organ in higher mammals (primates and human beings). Huschke did not have any specific idea about the function of the thyroid. The term "hormone" was introduced much later in the 20th century [29]. Because he could not detect an excretory duct in the thyroid, and taking into account the rich vascular supply, Huschke assumed that the thyroid took in hematopoiesis and was a "blood gland" ("Blutdrüse"). On the other hand Huschke did observe that the thyroid swells "in women at the beginning of their menstruation, after defloration and conception". He also observed an interesting case of a pathological thyroid enlargement. - "A tyrolean who traveled every summer from the Alps to Trieste, Venice and other Mediterranean regions for business, emigrated with a goiter and came back cured". Although Huschke knew about the healing power of iodine, he probably did not recognize the relation between the iodine-rich Mediterranean food and the protection against the development of a goiter [30].

As to other hormonal organs it should be mentioned, that Huschke probably was the first who used the terms "Nebennierenrinde" (adrenal cortex) and "Nebennierenmark" (adrenal medulla) when he described the morphology of the adrenal medulla [31].

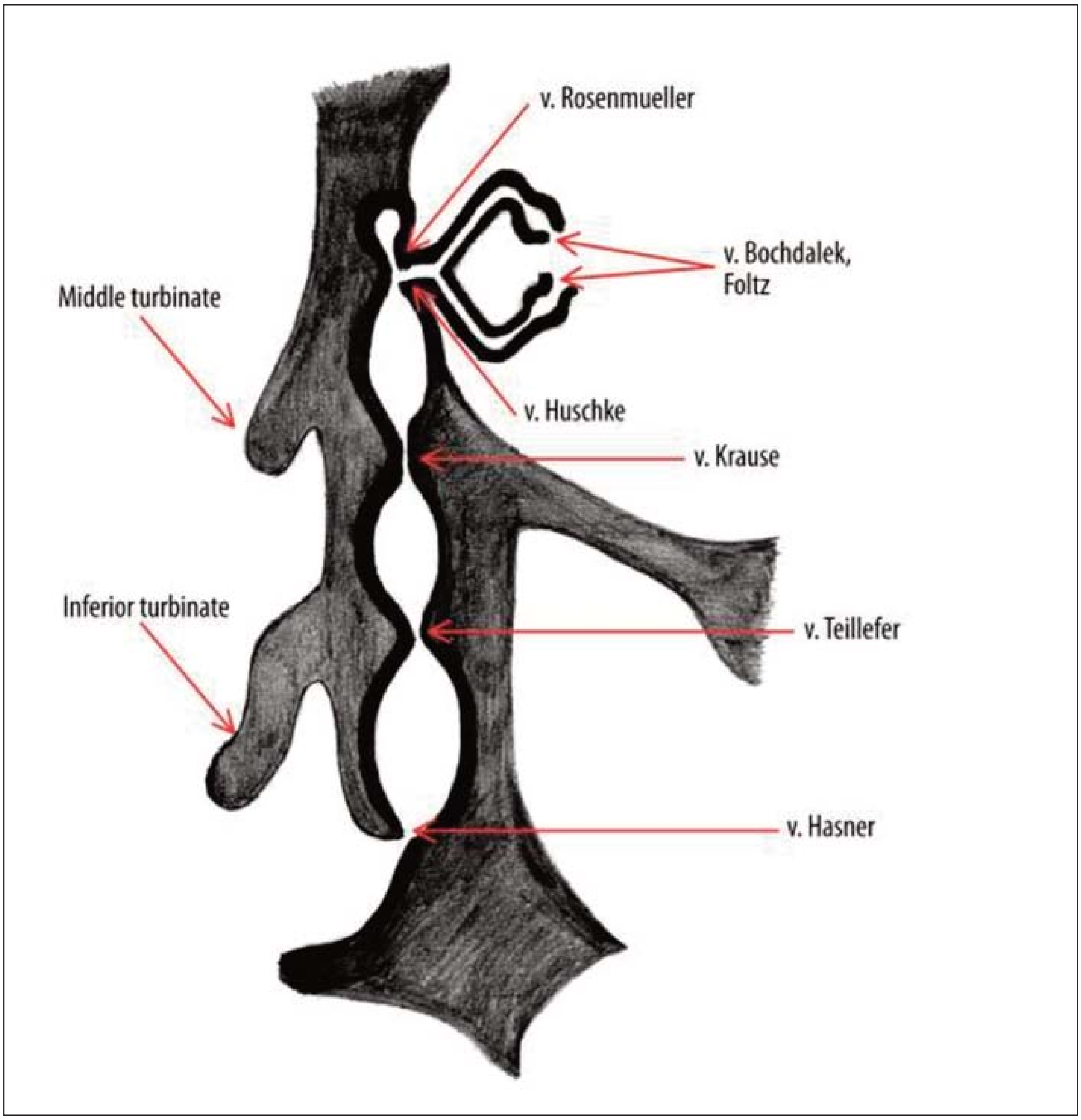

Fig. 12 Valves arrangement diagram of nasolacrimal drainage system. Based on Warwick R. Anatomy of the Eye and Orbit, 7th ed. Philadelphia: WB Saunders, 1976; 232.

Huschke's valve

Huschke's valve is a structure within the nasal cavity consisting of a tiny mucosal fold at the transition from the cananiculi lacrimales to the saccus lacrimalis (Fig. 12). In 1844 he noted that this lacrimal fold did not contain a sphincter [13]. Huschke's valve is more of a medical historical than a surgical interest.

Smell and taste

Huschke's natural-philosophical view following the school of Oken becomes evident in the statement: "All repetitions in nature are repetitions of the inferior element" [2]. He stated: "The olfactory bones and nasal turbinates are, therefore, the gills of the nose, which have become sensorial and are controlled by sensation ("Die Riechbeine und Muscheln sind also die sinnig gewordenen von der Empfindung beherrschten Kiemen der Nase") [2]. In the appearance of the olfactory bones Huschke distinguished far-distance smellers with sheet- and shell-shaped and near-distant smellers with branched olfactory bones. Among the former were the pigs and the ruminants, and the latter the carnivores, who were better able to sniff their prey. Huschke regarded all three senses (smelling, seeing, hearing) as ideal or far-distance senses (so called senses of air). On the contrary, he characterized taste and touch as material senses, because they require immediate contact of the sense organs with substance matter. He also called the sense of taste 'the sense of water'. By 1824, he had recognized that the taste buds and not the tongue itself were responsible for differentiated taste. In this he differed from the opinion of the anatomist Gottfried Reinhold Treviranus (1776-1837) who believed that the taste buds were only a tactile organ [2]. Today we differentiate between orthonasal and retronasal olfactory function and are able to test both functions separately. Huschke had already explained in his lecture "About the harmony of the six senses" at the court in Weimar on 13th April 1847 the dual character of the sense of smell [32]: "A gourmet finds satisfaction and inner fulfillment during eating and drinking only by expiratory odors developed during chewing. His tickle of the palate is indeed most often a nasal tickle. The countless, attractive flavors of ethereal oils in products of the confectioners and of liqueur manufacturers, the bouquet of wine, the delicate treats of meat and vegetable dishes, even the aroma of milk, butter and of fresh bread, all this we do not owe to the palate and tongue but to the olfactory nerves. The tongue is therefore a poor fellow against the nose. Its limited household offers only simple homemade food, the actual spice comes from its neighbor. But they keep up a good neighborhood. Their friendship is that intimate, that taste does not enjoy without olfaction. An advice to all gourmets is to maintain the health of the sense of smell and to protect against common colds. Common colds can affect the finest taste until it becomes dull" [33].

A remnant of the vomeronasal organ, originally created as an accessory olfactory system, can be found frequently at the inferior border of the cartilaginous part of the human nasal septum. This remnant terminates with a blind end [34]. Adjacently some small cartilaginous sticks can be found. Josef Hyrtl (1810-1894) proposed naming these sticks after Huschke, their discoverer: Huschke's nasal cartilage [35]. Huschke himself called them „Vomer cartilaginous dexter et sinister". It is controversial whether this Cartilago vomeronasalis has a supporting function at the entrance of the embryologically existing human vomeronasal organ [35].

A final anecdote

Huschke was a very important contributor to the future field of otorhinolaryngology. He was an outstanding and meticulous comparative anatomist. Many of his main discoveries and what he taught to his students are still part of the curriculum. He was an enthusiastic academic teacher, who prepared his lectures with painstaking care till the last. Even on his death bed, his thoughts still were with his academic lectures. There is an anecdote in his obituary that tells that despite being ill, about eight days before his death, he did not allow this to prevent him from giving his regular lecture in physiology. Then, his condition worsened and he was confined to his bed. His periods of unconsciousness became longer and were broken only when he suddenly awoke at the time when he would normally have delivered his lectures. In a feverish dream he gave a clear and coherent lecture about the subject he had planned to present at that time [33].

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