be used, as required, in connection with any other language employing the Roman alphabet. For example: the sign of nasality in Visible speech is ʃ; and this character might very conveniently replace the *n* and *m* used in French, as in '*bon*,' '*temps*,' '*enfin*,' etc. The peculiar sounds of *ch*, *g*, and *w*, in German, as in '*nach*,' '*ich*,' '*auge*,' '*wie*,' etc., have very simple representatives in the physiological alphabet, which might, with great benefit, be adopted in the Romanic writing of German. The following illustrations exemplify these suggested improvements in French and German phonetic writing: —

boʃ, teʃ, eʃfiʃ, naC, iↃ, auϵe, ɔie.
bon, temps, enfin, nach, ich, auge, wie.

The alphabet that expresses the speech of America, England, France, Italy, and Spain, is a wonderfully imperfect instrument; but it is more imperfect in relation to the sounds for which it is used in America and England than in the other countries. Common sense revolts at the unnecessary difficulties imposed on the young by those who have got over the difficulties for themselves; for it must be acknowledged that the efforts of spelling-reformers have been resisted on no better ground than that of conservatism of error and defect, because established. Orthography has been considerably modified for local uses in Spain, and, to a more limited extent, in France. To the English-speaking races remains the task of effecting greater modifications to remove not only local, but international difficulties. For this purpose the alphabet itself must be reformed. This paper shows how such a reform could most hopefully be commenced. But why not have two alphabets? The new letters, being purely phonetic, would be a key to old letters, not only in English, but universally; and then the venerated orthography of our literature might remain undisturbed.

ALEX. MELVILLE BELL.

A STUDY OF THE HUMAN TEMPORAL BONE. — II.[1]

THE *labyrinth* is a complex receptacle of the internal ear, embedded within the petrosa, with its long axis parallel with this, and occupying a position intermediate to the tympanum and the internal auditory meatus. Its cavity is enclosed with compact walls for the most part not distinctly differentiated from the rest of the petrosa. It consists of three portions, named the vestibule, the semicircular canals, and the cochlea.

[1] Continued from No. 14.

The *vestibule* is an irregularly ovoidal cavity situated between the tympanum and the internal auditory meatus, communicating with the cochlea forward and inward, and the semicircular canals backward and outward. In its outer wall is the oval window, opening into the tympanum, but closed in the complete condition by the base of the stirrup. At the fore-part of its inner wall is a circular concavity, the *hemispherical fossa*,[1] at the bottom of which is a little group of minute foramina named the *middle cribriform macula*. The fossa is defined by an acute margin, which expands at the roof of the vestibule in a low *pyramidal eminence*. This is perforated by a group of minute foramina, the *superior cribriform macula*. On the roof of the vestibule, outwardly and behind the fossa indicated, is another less defined, named the *hemielliptical fossa*.[2] At the lower part of this is the aperture of the fine venous canal,[3] which communicates with the cleft on the posterior surface of the petrosa. Below the oval window is the *cochlear fossa*,[4] which, in the prepared bone, communicates freely with the cochlea, but, in the recent state, opens only at its fore-part into the vestibular passage of the same. Externally, above and behind the hemielliptical fossa, the semicircular canals communicate with the vestibule.

The *semicircular canals* are three horseshoe-shaped tubes, traversing the compact substance of the petrosa outwardly from the vestibule, with which they communicate by five apertures. They are compressed, cylindrical, and each has one end expanded in a pyriform dilatation named the *ampulla*. The *posterior canal*[5] is longest, is directed vertically outward, and extends lowest; the *superior canal* is directed vertically fore and aft, extends highest, and produces the conspicuous prominence on the front surface of the petrosa; and the *external canal*[6] is shortest, and is directed horizontally outward on a level with the ends of the superior canal, and the middle of the posterior canal. The ampullae of the superior and external canals occupy their fore-ends, are contiguous, and open into the vestibule above the oval window. The ampulla of the posterior canal occupies its lower end, and opens into the lower back part of the vestibule. The hind-end of the superior canal, and the upper end of the posterior canal, conjoin in a common canal, which opens into the upper back part of the vestibule; and the hind-

[1] Fossa hemispherica, recessus sphaericus.
[2] Fossa hemielliptica, recessus ellipticus.
[3] Aqueduct of the vestibule.
[4] Recessus cochlearis.
[5] Internal or inferior.
[6] Median, horizontal, least.

end of the external canal opens into the latter at its middle back part.

In the ampulla of the posterior semicircular canal is a little circular group of minute foramina, the *inferior cribriform macula*.

The *cochlea*, named from its resemblance to a snail-shell, is situated inwardly, and in advance of the vestibule. It is a broad, low cone, placed on edge, with its base applied behind to the bottom of the internal auditory meatus, with its axis directed forward and a little outward, and with its apex contiguous to the eustachian tube and the bend of the carotid canal. Externally it produces the promontory, and internally its wall is separated from the exterior compact layer of the petrosa by the spongy substance occupying the interior of the apex of the latter.

The cochlea consists of a cylindroid, slightly tapering tube, the *cochlear canal*, which winds spirally round a central column, named the *modiolus*. The tube makes nearly three turns, gradually projecting in its course, and ending in a rounded summit, the *cupola*. From the round and oval windows, the cochlear canal turns downward, inward, upward, and outward, and continues in the same relative course to the end.

The *modiolus*, or central column of the cochlea, is conical, with a broad base excavated and impressed by the spiral tract at the bottom of the internal auditory meatus, and with its apex terminating immediately behind the end of the cochlear canal. In the course of the latter, the modiolus undergoes a rapid reduction, and, in the view of a longitudinal section of the cochlea, appears as a short, wide, cylindrical column, with a second short and narrow one projecting centrally from the former. From the middle of the modiolus, in the course of the cochlear canal, there projects a thin shelf, named the *spiral lamina*. This reaches about half way across the canal, partially dividing it into two passages. In the complete condition of the labyrinth, a membranous tube, the *cochlear duct*, extends along the cochlear canal, between the spiral lamina and the opposite wall, and completely separates the two passages. Of these, one communicates with the round window of the tympanum, and is hence called the *tympanic passage*,[1] while the other communicates with the vestibule, and is named the *vestibular passage*.[2] The two passages communicate with each other at the summit of the cochlea, within the cupola, by a common orifice.[3]

The turns of the cochlear canal being contiguous, in a longitudinal section of the cochlea, they appear separated by a partition extending from the modiolus to the periphery of the cochlea and gradually thickening as it approaches the latter. The partition is thickest at its commencement, and gradually becomes thinner in its course, until it abruptly terminates in a crescentic edge extended between the apex of the modiolus and the cupola. The interior surface of the cochlear canal, exclusive of the modiolus and spiral lamina, is imperforate and smooth. Opposite the spiral lamina it is commonly marked by a faint line, indicating the attachment of the spiral ligament.

The surface of the modiolus curves continuously from this into the surfaces of the cochlear canal and spiral lamina. In transverse section the canal appears more or less reniform.

The spiral lamina is widest at its commencement, opposite the round window, gradually narrows in its course, and ends in a hook-like process[1] projecting from the apex of the modiolus. At its commencement a narrower portion[2] is continued around to the opposite side of the cochlear canal, where it arches over the round window. The anterior surface of the spiral lamina is directed into the vestibular passage. A groove along its middle divides it into two zones, of which that next the free edge is the more compact and even. The posterior surface looks into the tympanic passage. The free edge is rounded and minutely serrulate.

The surfaces of the modiolus and spiral lamina are minutely porous for the transmission of vessels and nerves; and this condition is more marked within the tympanic passage.

Commonly a row of larger elliptical foramina, or pits, is situated within the latter passage, along the root of the spiral lamina, extending on the modiolus, giving this position a fluted appearance. The arrangement is of variable regularity, sometimes interrupted, and at times obscure. A narrower row of smaller and more numerous foramina occupies the base of the modiolus within the same passage. A row of small foramina is also variably conspicuous at the bottom of the modiolus, contiguous to the spiral lamina in the vestibular passage. Within this, also, the modiolus is more or less marked by minute radiating grooves, which advance and branch on the anterior surface of the passage.

The modiolus is composed of fine spongy substance defined by a thin, more compact layer. It is traversed by a *central canal*, for the transmission of an artery, commencing at the central aperture of the spiral tract, and

[1] Scala tympanica. [2] Scala vestibuli. [3] Helicotrema.

[1] Hamulus. [2] Lamina spiralis secundaria.

ending at the apex of the modiolus. A larger *spiral canal* traverses it just behind and along the course of the spiral lamina, for the accommodation of the spiral ganglion. Numerous fine canals, communicating with the minute foramina of the spiral tract, likewise traverse the modiolus, for the transmission of the filaments of the cochlear nerve. The canals in their advance are successively reflected to open into the spiral canal of the modiolus.

The spiral lamina is composed of two delicate compact layers, with an intervening delicate spongy layer, which is traversed with numerous fine radiating and anastomosing canals. These communicate with the spiral canal of the modiolus, and terminate in minute apertures at the free edge of the spiral lamina.

The tympanic passage of the cochlea is directed from the round window downward, forward, and inward. It is crossed below, just in advance of the window, by a little crest,[1] to the inside of which is the aperture of the fine venous canal communicating with the pyramidal pit of the jugular foramen. The vestibular passage communicates with the vestibule internally to and above the tympanic passage, and below the position of the oval window.

The round window looks outwardly from the tympanic passage into the arched recess at the back of the promontory. It is beneath and a little external to the position of the oval window, from which it is separated by a vaulted arch formed by the upper part of the promontory. It is irregularly circular or somewhat oval, and about a third less in size than the oval window.

[1] Crista semilunaris.

GLACIAL DEPOSITS OF THE BOW AND BELLY RIVER COUNTRY.

DURING the progress of the geological examination of the Bow and Belly River country, which lies for the most part in the drainage-area of the South Saskatchewan, north of the 49th parallel, and immediately east of the base of the Rocky Mountains, several points of considerable interest and importance in the history of the glacial period have been observed. These observations, though made in the summer of 1881, have not yet been published; and, as it is hoped that the work of the coming season may add largely to our knowledge of this and neighboring districts, a detailed report is likely to be still further deferred. A brief general notice may in the mean time be of interest to the readers of SCIENCE.

A systematic account of the 'surface geology' of this and other districts in the vicinity of the 49th parallel was first given by the writer in 1875.[1] Observations were, however, at that time, necessarily confined more or less closely to the neighborhood of the 49th parallel. The late examination of the Bow and Belly country has been much more complete, embracing an area of about 20,000 square miles. The surface of this region declines, but not uniformly, from a height exceeding 4,000 feet along the base of the mountains to about 2,500 feet in its eastern and north-eastern parts. With the exception of a strip of country which may be designated as the foot-hills of the Rocky Mountains, the whole of this tract is covered more or less deeply with material which may be generally referred to as 'drift.' Over considerable areas this covering is from 100 to 200 feet in thickness; but in other places it is comparatively scanty, particularly on some of the more elevated plateaus of cretaceous and Laramie rocks. During later tertiary time the country has evidently been subjected to very extensive denudation; and its surface must have been much more diversified at the onset of the glacial period than it is at present. The drift deposits have evidently filled pre-existing hollows and low tracts; and the general effect has been a filling-up of its irregularities, and the production of wide areas of almost level prairie country. In cutting out their beds anew in the modern period, the rivers have in some places exposed fine sections of the cretaceous and Laramie rocks, while in others the base of the drift deposits has not been reached.

Resting immediately on the surface of the cretaceous and Laramie rocks in a number of localities on the Bow, Belly, Old Man, and other rivers, is a deposit of well-rolled pebbles or shingle, consisting, for the most part, of hard quartzites, and derived entirely from the paleozoic rocks of the Rocky Mountains. These pebbles are seldom more than a few inches in diameter, and often very uniform in size. The deposit has been observed to extend to a distance of over a hundred miles from the base of the mountains. Whether it has been carried from the mountains entirely by the action of rapid streams of preglacial times, or has been distributed in some more extended body of water, I am as yet unprepared to decide; but the fact that it occurs at very different elevations above the present water-level in neighboring sections on the same river, would appear to point to the latter conclusion. No marks of ice-action have been found on the stones of this deposit, which at one place on the Belly

[1] Quart. journ. geol. sce., Nov., 1875. Geology and resources of the 49th parallel.