no means uniform. There are at times distinct steps, which are sometimes visible as such, on the surface of the incoming water. At other times the water holds its level for a short interval, and then rises rapidly afterwards to make up, as it were, for lost time.

The diagram may also be taken to represent the form of the bore, or its profile along the river at any given moment. Strictly speaking, this involves the assumption that the whole mass of water moves forward at the same speed as the broken front which forms the bore itself; which in all probability is not very far from the truth. To assist this view, a scale of distances is given on the diagram, which is based upon the average rate of advance of the bore in running up the river.

The bore itself is clearly the broken water at the front edge of a long water-slope which advances up the river. The greatest rate of rise at spring tides after the bore has passed amounts to 3·00 feet in 10m. 5s.; and if we take for the average speed 8½ miles per hour, the equivalent water-slope is 2·10 feet per mile. This slope appears very moderate in the circumstances, although it is really greater than in most rivers, except where rapids occur. Also, as a question of hydraulics, this slope would undoubtedly prove to be in correspondence with the speed of the currents following the bore, if the problem were fully worked out.

It is said that formerly the bore used to be higher than at present, owing to changes that have taken place in the bars in the river, which now obstruct the channel at low water and interfere with its development. No very definite information could be obtained as to this.

On August 22, 1892, a good photograph of the bore was obtained, which has been published in a report of the Geological Survey. Its height as then measured was 5 feet 4 inches. It is clear, from the observations, that in three to four minutes after the bore passes the water has already risen an extra foot. The greatest height which was measured in the above observations was 3 feet 3 inches, although it would be a little higher at the middle of the river. This may probably be taken as a fair average at ordinary spring tides. The maximum no doubt occurs when the moon is in perigee at full or change, and also at its maximum declination, as this gives the greatest difference in favour of one of the two tides in the day. Something also depends on the level to which low water falls, as this practically adds to the height of the bore. The total difference, however, in the level of low water between spring and neap tides, and between one set of spring tides and another, was found to be little more than one foot altogether, as observed in the summer season. Late in the autumn, when the fresh water outflow of the Petitcodiac is increased, the water surface at low tide does not fall so low.

The time of the arrival of the bore, with reference to the time of high water, was worked out from the observations obtained while the tide gauge was being erected. The time of high water at Moncton was obtained by difference of establishment, from the tide tables for St. John. The comparison shows that the time of arrival of the bore varies from 3h. 1m. to 3h. 34m. before the time of high water. This result may, however, be subject to revision.

It is hoped that the arrival of the bore, being a well-defined moment, may serve to throw light on the whole question of the progress of the tide in the Bay of Fundy.

The only other place in the Bay of Fundy at which the bore has been seen is in the upper part of Cobequid Bay. The tide there used to arrive as a bore at Maitland, at the mouth of the Shubenacadie River; but a change in the position of the sand bars below Maitland now prevents this. In running up the Shubenacadie, however, the tide still breaks occasionally into a ripple or miniature bore.

THE BOYLE LECTURE ON THE PERCEPTION OF MUSICAL TONE.

On Tuesday, June 6, Prof. McKendrick delivered in the Lecture Room of the New Museums, Oxford, the annual Boyle Lecture, the subject being the perception of musical tone. The lecture was entirely devoted to a consideration of the functions of the cochlea, the minute anatomy of which was fully described. The internal ear consists of a complicated series of sacs and tubes filled with fluid. In certain situations the walls of the sacs contain highly differentiated epithelial structures, which are intimately related to the terminal filaments of the auditory nerve. The problem is to explain how the pressures transmitted by the foot of the stapes affect these terminal structures in such a way as to excite sensations corresponding to the pitch, intensity, and quality of tone. The dimensions of the internal ear are so minute as to form only a small part of the wave-lengths, even of tones of high pitch. The nerve endings are still smaller, but they also act as minute portions of any wave, and any reasoning as to the effect of such waves is quite irrespective of the small dimensions of the receiving organs in the internal ear. If we consider a wave of sound as a series of states of condensation and states of rarefaction, travelling on continually in one direction; and, further, if we remember that the motion of each individual particle forming the wave is very small, and is alternately backwards and forwards, in the same line as that in which the wave travels, we see that the movements, inwards and outwards of the base of the stapes, correspond to these oscillations, or, in other words, to increase and diminution of pressure with each wave. Some of the possible movements of the base of the stapes were described, along with their action on the perilymph surrounding the utricle and saccule. We can hear musical tones and noises, we have a peculiar auditory sensation to which we give the name of beats, and we have the power of analysing a musical tone into its component parts. A demonstration was then given of the limits of pitch perception, of beats, and of beat tones. As regards the perception of intensity, the results of inquiries made by Töpler and Boltzmann, and more especially by Lord Rayleigh, showed the delicacy of the ear for sound, as regards energy, is about the same as that of the eye for light. The ear may be affected by vibrations of molecules of the air not more in amplitude than ·0004 mm., or 0·1 of the wave-length of green light; while Lord Rayleigh says "that the streams of energy required to influence the eye and ear are of the same order of magnitude." The question of analysis was next considered, and the bearing on it of Ohm's principle and Fourier's theorem, as regards wave-forms. The lecturer stated that on the whole he was not yet satisfied from any observations he had been able to make that the ear took cognisance of differences of phase, and he pointed out the peculiar difficulties in making observations on this point. He was still inclined to support the views of Helmholtz. Illustrations were given of wave-forms as revealed by the phonograph, and an instrument enabled the audience to hear experiments on pitch, intensity, and quality. Several violin records of rare beauty were reproduced. The lecturer next discussed the probable action of the cochlea. There are only three ways in which the ductus cochlearis, which contains the nerve-endings, may be affected. Either (1) small vibratile bodies may exist between the pressures sent into the organ and the filaments of the auditory nerve, each vibratile body having a frequency period of its own; or (2) individual nerve-fibres may be directly excited by waves of a definite period—that is to say, there may be differences in the nerve-fibres, so that they have a selective action; or (3) the organ may be affected as a whole, all the nerve-fibres being affected by any variations of pressures, and thus the power of analysis, which is admitted, is relegated from the peripheral to the cerebral organs. The first hypothesis seems most probable, for (1) the existence of such bodies would give a natural explanation of many, if not all, of the phenomena; (2) the evidence of comparative physiology points to a gradually increasing complexity in the structure of all the terminal organs of special sense, as there arose a necessity for differentiation and discrimination in the effects of various kinds of stimuli; and (3) investigations into the action of all the sense-organs, such as those of touch and temperature in the skin, of light and colour in the retina, of taste in the tongue, and of smell in the olfactory region—all indicate specialisation of function in the peripheral apparatus. The action of the cochlea was then fully described, and stress was laid on the movements of segments of the membrana basilaris causing contacts between the apices of the hair-cells and the under-surface of the membrana tectoria. Suppose that, in accordance with the view of Helmholtz, a segment of the basilar membrane were thrown into sympathetic vibration, it would move in a direction at right angles to the direction of its fibres. These movements would be communicated to the structures lying on its upper surface, and if we suppose the arches of Corti to be elastic, such movements would be transmitted to the hair-cells. These would move in the line of their long axis; in other words, their hairs would move up and down in the meshes of the membrana reticularis, and strike against the under surface of the membrana tectoria. A reaction would take place from the latter, and thus the delicate nerve-endings between the hair-cells would receive pressures corresponding in frequency to the oscillations of the membrana basilaris. In the cochlea of birds and amphibia, the mechanism is practically the same, but in consequence of the membrana basilaris not being highly differentiated, there cannot be the nice discrimination of pitch of tone which exists in the higher animals. The lecturer gave reasons for holding that a bird has a power of discriminating pitch only through a narrow range. These views were also, on the whole, supported by pathological observations in cases of deafness, and of the deafness of boiler-makers in particular. In the latter there is the loss of perception of high tones, and degenerations are observed in the lower whorl of the cochlea, as is required by theory. The action of the cochlea, as thus conceived, was demonstrated with a model. The lecturer also gave a large number of measurements of parts of the ear, showing that there were a sufficient number of structures in the cochlea to enable us to detect differences of the 1/64th of a semitone, thus amplifying the conclusions reached long ago by Helmholtz. The number of nerve-fibres in each cochlear division of the auditory nerve is about 14,000, giving something like 1250 for each octave through the eleven octaves of audibility. Assuming that the number of auditory filaments is the same for each of the eleven octaves (an unlikely supposition, as there will probably be a larger number of filaments for octaves in the middle of the range of the ear), there will still be two filaments for each 1/64th of a semitone; while, for the same interval, there will be three fibres of the membrana basilaris, and two hair-cells. The production of combination tones, differential and summational, was next considered, the lecturer stating that, in his opinion, and founded on experiment, both had an objective existence. They are not beats, but true sounds superadded to the generators, and thus they fall within the scope of Ohm's law. The theories, other than that of Helmholtz, were then criticised; namely, those of Rutherford, Waller, Hurst, and the more recent one of Max Mayer. The most obvious objection to any theory which dispenses with peripheral analysis is that it leaves the exceedingly elaborate structure of the organ of Corti, and indeed of the cochlea, as a whole, out of account; or, to put the matter in another light, it assigns to that organ a comparatively simple function. Ohm's law also may be subject to certain limitations, but there is no substitute for it. Max Mayer agrees with Hurst in imagining a series of waves transmitted along the scalæ, instead of the scalæ forming part of one wave. The two differ in respect that Max Mayer supposes, on physical grounds, that the amplitude must diminish from base to apex of the cochlea; while Hurst argues, also from the physical point of view, that the amplitude must increase. This is a serious discrepancy, inasmuch as Mayer's theory rests wholly on the supposition of diminished amplitude. It seems impossible to conceive of minute waves following each other in rapid succession in the minute tubes forming the scalæ. These theories are independent of the principle of sympathetic resonance, imperishably associated with the name of Helmholtz, and which still, in the lecturer's opinion, holds the field. Lastly, the lecturer pointed out that the roots of the auditory nerves were probably more widely distributed and had more extensive connections than those of any other nerve. The intricate connections of these nerves were only being unravelled. This pointed to an explanation of how music penetrates to the very roots of our being, influencing by associational paths, reflex mechanisms, both cerebral and somatic, so that there was scarcely a function of the body that might not be affected by the rhthymic pulsations, melodic progressions, and harmonic combinations of musical tones.

THE DARMSTADT MUSEUM.

THROUGHOUT the civilised world attention is being concentrated on the improvements in the mode of arranging specimens in the exhibition galleries of natural history museums; so that they should be both attractive and instructive to the general public, and at the same time useful to the student. Nowhere does this advance seem more marked than at Darmstadt, where the Director, Dr. G. von Koch, has just published an interesting and well illustrated progress report ("Die Aufstellung der Tiere im neuen Museum zu Darmstadt," Leipsic, 1899.)

We gather from this report that a large proportion of the museum is devoted to the systematic classification of animals; and it is gratifying to observe that not only are skeletons and skulls ranged side by side with the mounted skins, but that anatomical preparations and remains of extinct forms are introduced in their proper serial position. A notable feature (in the seventh gallery) is the exhibition of a series of economic animal products, such as furs, wool, leather, ivory, tortoise-shell, mother-of-pearl, shell, coral, &c. But the greatest novelty is the formation of a gallery (the eighth in the series) illustrating the geographical distribution of animals on the globe. And here, instead of arranging the specimens on the conventional wooden stands on tier upon tier of shelves, an attempt has been made to reproduce the natural surroundings of their habitat.

To take, for example, the South and Central American region, we find, as shown by one of the plates accompanying the report, alligators, tapirs, carpinchos, chajas, &c., occupying the low land by the river. In the adjacent forest tract we have anteaters, sloths, coatis, pacas, opossums, armadillos and the characteristic monkeys. On a higher level we have the open pampas and llanos, with peccaries, brockets, pumas and rheas; while the background of the scene is formed by mountain peaks tenanted by guanacos, vicugnas and condors. Birds of other kinds are likewise introduced in appropriate positions so far as the limits of space permit. Similar scenes represent the other great zoo-geographical regions; and it is important to notice that the whole series is ushered in by the fauna of Hessen-Darmstadt itself.

It would undoubtedly add much to the interest and instructiveness of our own natural history museums if arrangements could be made for the formation of galleries of economic and distributional zoology on somewhat similar lines.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—A number of the foreign guests who had been present at the Stokes jubilee celebration and the Royal Institution centenary were invited to Oxford on the 8th, and were entertained at a luncheon in Christ Church. Among those who came were Profs. Arrhenius, Barker, Barus, Becquerel, Bleekrode, Ciamician, Cornu, Deslandres, Franchimont, Egoroff, Gautier, Körner, Le Chatelier, Liebreich, Martius, Michelson, Moissan, Nasini, Newcomb, and Sivewright.

In a convocation held the same day, the honorary degree of D.C.L. was conferred upon Profs. Becquerel, Körner, Liebreich, Moissan and Newcomb.

The following were the speeches made by the Regius Professor of Civil Law, Dr. H. Goudy, in presenting them.

Nihil pulchrius nobisque optatius est quam viros e gentibus externis de scientiarum studiis optime meritos societati nostrae adscribi atque arctissimo et dignitatis et amicitiae nobiscum vinculo consociari. Quae res hodie Universitati nostrae contigit quae eos viros, quos mihi adstare videtis, communi omnium ejus membrorum consensu (Instituti quod dicitur Regii annum centenarium feliciter actum commemorans) insigniri jussit.

BECQUEREL.

Primum ad vos duco virum illustrem, Gallica stirpe oriundum, qui in scientia physicae famam eximiam est adeptus, patris in eadem scientia illustris filius. Physicae studiosorum in manibus sunt scripta ejus praeclara principiis scientiae illius illustrandis destinata. Operum numerum quorum auctor doctus ille exstitit referre longum est; neque tamen, ut plurima praeteream, silentio praetereunda videntur opuscula illa, publici juris facta, in quibus de magnetis et electri proprietatibus felicissime disseruit, ipsamque Naturam, rerum creatricem, in lucem proferre coegit quanam ratione quaedam corpora aliquando lumina emittant atque vires electricas eis transmissas per longum tempus retinere possint.

KÖRNER.

Praesento vobis virum egregium, Germanica stirpe oriundum, inter eos qui praecipuam curam rebus chemicis dederunt notissimum. Quantum in ea parte Naturae profecerit, quam multa ingeniose et subtiliter excogitaverit, mihi exponere minime concedit sermonis academici egestas! Quid de compositis aromaticis ab eo recte libratis, quid de ἰσομοιρία, ut Graeco utar vocabulo, corporum in conjunctione naturali disseram?