C. Dallas; an Algerian Skink (*Eumeces algeriensis*) from North Africa, presented by Mr. R. H. Archer; a Rufescent Snake (*Leptodira hotambaeia*), a Hissing Sand Snake (*Psammophis sibilans*) from South Africa, presented by Mr. W. Champion; three Barbary Turtle Doves (*Turtur risorius*) from Africa, presented by Colonel E. J. Gardiner; three Blue-necked Cassowaries (*Casuarius intensus*) from New Guinea, a Senegal Parrot (*Paeocephalus senegalensis*) from West Africa, two Mute Swans (*Cygnus olor*, 2 ♂), European; an Echidna (*Echidna hystrix*) from New South Wales, deposited; a Hunting Crow (*Cissa venatoria*) from India, three Bar-tailed Godwits (*Limosa lapponica*), four Black-tailed Godwits (*Limosa aegocephala*), ten Green Lizards (*Lacerta viridis*), four Toads (*Bombinator bombinus*), European, purchased; a Japanese Deer (*Cervus sika*, ♂), an English Wild Cow (*Bos taurus*), two Squirrel-like Phalangers (*Petaurus sciureus*, 2 ♀), two Short-headed Phalangers (*Petaurus breviceps*, 2 ♂), a Patagonian Cavy (*Dolichotus patachonica*), a Crested Porcupine (*Hystrix cristata*), a Hybrid Lemur (between *Lemur macaco* and *Lemur brunneus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

TEMPEL'S COMET (1873 II.)—Continued from *Astr. Nach.* (Bd. 149, No. 3554).

Ephemeris for 12h. Paris Mean Time.

1899.		R.A. h. m. s.		Decl. ° ′ ″		Br.
June 15	...	19 54 47·2	...	− 5 12 25		
16	...	56 11·5	...	5 22 24		
17	...	57 35·4	...	5 33 2	...	1·829
18	...	19 58 58·9	...	5 44 20		
19	...	20 0 21·9	...	5 56 19		
20	...	1 44·5	...	6 8 59		
21	...	3 6·7	...	6 22 21	...	2·048
22	...	4 28·5	...	6 36 27		
23	...	5 49·8	...	6 51 16		
24	...	7 10·7	...	7 6 49		
25	...	20 8 31·1	...	− 7 23 7	...	2·281

The comet is now more than four times as bright as when it was first re-observed by Prof. Perrine at Lick on May 6. Perihelion passage occurs on the 18th inst. During the period included in the above ephemeris the comet travels from the south-eastern part of Aquila to the north-west of Capricornus, being about 5° due north of α Capricorni on the 25th.

RETURN OF COMET HOLMES (1892 III.).—Continued from *Astr. Nach.* (Bd. 149, No. 3553).

Ephemeris for 12h. Greenwich Mean Time.

1899.		R.A. h. m. s.		Decl. ° ′ ″		Br.
June 15	...	1 22 38·3	...	+18 47 18	...	0·0341
17	...	22 56·5	...	19 23 22		
19	...	29 13·8	..	19 59 19		
21	...	32 29·9	...	20 35 8	...	0·0351
23	...	35 44·9	...	21 10 50		
25	...	38 58·8	...	21 46 25		
27	...	42 11·4	...	22 21 51	...	0·0362
29	...	1 45 22·7	...	+22 57 10		

During the above period the comet moves from near η Piscium to about 2 degrees north of β Arietis.

A telegram from Kiel, dated June 12, announces the first detection of this comet by Prof. Perrine at the Lick Observatory. The observation was made on June 10, at 15h. 2·2m. Lick Mean Time, the recorded position being

R.A. = 1h. 15m. 32s.
Decl. = + 17° 29′ 39″,

which will be seen to be fairly in agreement with the computed position. The comet is described as being very faint.

COMET 1899 *a* (SWIFT).—A circular from the Central Bureau at Kiel calls attention to the importance of the increase of brightness of this comet, which was recorded by several observers on June 4 last. Herr Kreutz has received a telegram from Herr Pokrowsky, of Dorpat, stating that communications received by him from Vienna, Bamburg and Hamburg, confirm the fact that on June 4 a decided brightening of this comet took place. The increase of magnitude was from 6 on June 2nd and 3rd to 5⅓ on the 4th. A telegram also from Herr Hartwig gives further details. "The nucleus was of 9·5 magnitude, the total brightness being of magnitude 5. Greatest diameter of Coma about 9′; increase of brightness undoubted."

Another, from Herr Schorr, states: "Strong eccentric fixed star-like nucleus of 6·5 magnitude. Total brightness of comet 5 magnitude. Coma 9′ in diameter."

It will also be remembered that there was a decided increase in brightness of this comet from May 9 to 23, after which it gradually began to decline until the above sudden change was noted.

WHITE SPOT ON JUPITER.—Herr Ph. Fauth, writing from a private observatory at Landstuhl to *Astr. Nach.* (Bd. 149, No. 3570), announces the observation on several occasions of a brilliant white spot on the north-eastern belt of the planet. The marking was observed to pass central meridian on May 8 at 11h. 25m., and on May 18 at 9h. 33m. It is about 4″ in diameter. The observations were made with a telescope of 7 inches aperture.

TWO NEW VARIABLE STARS.—M. Luizet, of the Lyons Observatory, announces in *Astr. Nach.* (Bd. 149, No. 3570) his observations leading to the discovery of two new variable stars in the constellations Vulpecula and Cygnus respectively.

The first is U Vulpeculae,

B.D. + 20°·4200. R.A. = 19h. 30m. 17·3s. }
Decl. = + 20° 0′·8. } 1855·0.

Four comparison stars were used and forty-three observations made during the period August 4 to December 26, 1898. These observations after reduction are plotted as the light curve, which is symmetrical and similar to that of ζ Geminorum. A maximum was found to fall on the date

1898 October, 21·61 Paris Mean Time,

and this in conjunction with a previously observed maximum by MM. Müller and Kempf,

1897 October, 2·4765 Paris Mean Time,

gives the period as

8·003 days.

The elements of the star U Vulpeculæ are therefore adopted as

1897 October, 2·4765 Paris M.T. + 8·003d. E.

The second variable is S U Cygni, the position being

B.D. + 28°·3460. R.A. = 19h. 39m. 1·0s. }
Decl. = + 28° 54′·9. } 1855·0.

Fifty-eight observations of this star were made from July 9 to December 26, 1898, and the results again plotted to give the light curve.

The period is determined to be

3·846d.,

and succeeding maxima may be calculated from the elements:

1897 October, 4·6665 Paris M.T. + 3·846d. E.

This star has a light curve showing an *irregular* decrease of brightness from maximum during about 2·7d., and a more regular increase during 1·1d., these features showing the variability to be somewhat analogous to that of δ Cephei.

THE BORE AT MONCTON, BAY OF FUNDY.[1]

MONCTON is situated on the Petitcodiac River, nineteen miles above the mouth of the Petitcodiac, where it enters the Bay of Fundy. This part of the river is more correctly an estuary which continues thirteen miles further up, as far as Salisbury Junction. At high tide the river at Moncton forms a sheet of water half a mile in width, while at low tide it consists of mud banks and flats, with a stream about 500 feet wide

[1] Abridged by Prof. G. H. Darwin from an advance copy of the Report for 1898 of the Tidal Department of the Survey of Canada, sent by Mr. W. Bell Dawson.

running with a strong current in a devious channel amongst the bars and mud flats, which are left dry at low water.

The run of the rising tide first breaks into a bore at Stony Creek, eight miles below Moncton, and it continues to the head of the estuary at Salisbury, thirteen miles above. The total distance on the river that a bore occurs is therefore twenty-one miles.

With regard to the time of arrival of the bore at Moncton, this really corresponds with the time of half tide. At the central moment between the previous and the following high water, which we may term the theoretical time of low water, the level of the water in the river is still falling; and it continues to fall, though at a much slower rate, for about three hours longer before the bore arrives. The time of the arrival of the bore is thus only about three hours before the next high water, which serves to account for the very rapid rise which takes place after the bore passes.

The rate at which the tide falls amounts at its maximum to eight feet per hour; but after the theoretical time of low water, the rate of fall soon becomes very slow, and the river appears to a casual observer to remain at the same level for some two hours before the arrival of the bore. The flow, however, continues to be fairly swift; and it no doubt still consists of tide water. The rate of fall in the level of the water, as measured shortly after spring tides, was found to be as follows:—

From $4\frac{1}{2}$ to $2\frac{1}{2}$ hours before arrival of bore, rate of fall *six inches* per hour.
,, $2\frac{1}{2}$ to 1 hour ,, ,, ,, ,, *four inches* ,,
,, 40m. to 15m. ,, ,, ,, ,, *three inches* ,,

The first observation of the bore was made on the evening of August 4. The point of view commanded some two or three miles down stream below the bend, as well as the foreshore opposite Moncton. The moon was a little past the full, and was well risen before the bore arrived; and the sky was then clear also. There was a very slight breeze, and in the stillness sounds could be distinctly heard. It was thus at the spring tides, and twenty-four hours after the lowest of the tides at that moon.

The first sound of the approaching bore was heard at 23h. 8m., in 60th meridian time, and two minutes later the sound was quite distinct. This sound was very similar to the noise of a distant train when heard across water. It afterwards increased to the usual hissing and rushing sound of broken water, as in a rapid on a river; but there was no mingling in this sound of any roar, such as a waterfall makes when falling into deep water, even from a moderate height. The bore arrived at the wharf at 23h. 19m., or eleven minutes after its sound was first heard. The rapidly-flowing layer of incoming tide advanced over the current of the river in the opposite direction, with a front of broken and foaming water, which had a height of perhaps two or three feet. The front edge was by no means straight. The higher part of the bore extended across the waterway, and this was bent back and also heightened in the middle by the opposing current of the river, which is naturally swiftest at the centre of the stream. Beyond this the bore formed a long sweep, where it broke over the flats, retarded and decreasing in height towards the further bank of the river.

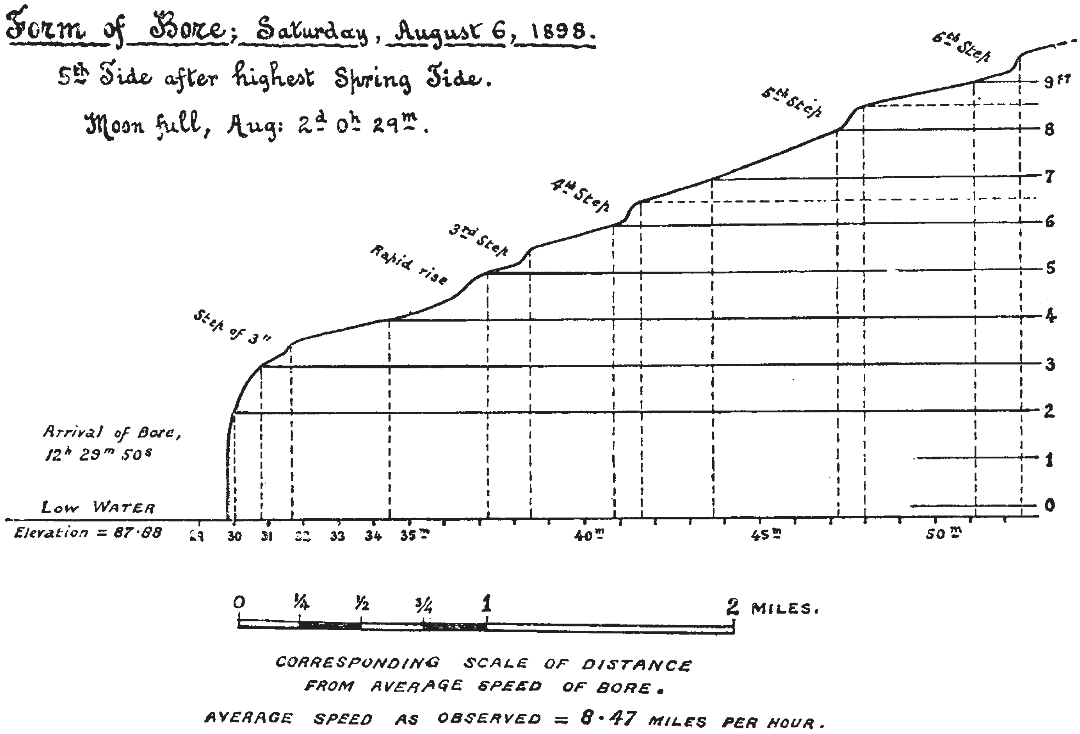
The surface current of the water following the main front has the same speed of flow as its rate of advance; and after the main front passes, there usually follow a series of others, stepped up a few inches of additional height. These form irregular lines of curve across the surface of the advancing tide, which do not extend far without interruption. These may be due in part to back-wash from the flats into the main channel. As seen in the day-time, the water forming the bore is excessively muddy and reddish-yellow in colour, just as the outflowing water of the river also is. The actual broken water in the front is nearly white, except at the shore end; but the long edge of the advancing water on the flats appears nearly black in strong sunlight. With a stiff breeze down stream, the sound of the bore cannot be heard till it has approached within a few hundred yards.

During the neap tides the bore still appears, and the front edge usually breaks a few inches high. But there are times when it consists merely of a heavy ripple, like the side waves from the bow of a steamer when they are advancing over still water; and it then only breaks occasionally, except in passing over the flats.

The rate of advance of the bore was timed from a point of observation on one of the upper wharves, which commands a view around the bend of the river. The velocity, as determined from several observations, was about $8\frac{1}{2}$ miles an hour.

To ascertain the form of the bore, and its rate of rise, a graduated board 13 feet high was set up in the front of the wharf, at which the tide gauge was placed. The current, after the bore passes, appears to have the same surface velocity as the rate of advance of the bore itself.

The height of the bore, as observed at spring and neap tides, and the rise of the water following it, are shown in the report by diagrams, of which one is reproduced here. The rise is by



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