were to continue to increase indefinitely, an organ resembling the highly developed structure in the Mormyridæ would result. This latter then may be looked upon as homologising with the valvula cerebelli and its wings in the ordinary teleostean.

With regard to the body which is placed behind the cerebellum, the author points out that the Cyprinidæ possess a well-known tuberosity occupying a corresponding position, which is termed by writers the tuberculum impar; this, in conjunction with the vagal tuberosities of the medulla oblongata, presents layers comparable to those existing in the structure in question belonging to the Mormyridæ; he therefore suggests that the homology of this exaggerated tuberosity in these fishes is to be looked for in the tuberculum impar together with the vagal tuberosities of the Cyprinidæ, the increased size in the former species having caused it to include the origin of the trifacial in addition to that of the vagus.

In conclusion, the author offers some criticism of the ideas lately put forward by Fritsch* as to the homologies of the various parts of the brain in fishes, the key to the whole of which lies in his interpretation of the tecta lobi optici, which he takes to be the persistent cortex of the primary anterior vesicle† of the brain of the embryo, and consequently to belong to the thalamencephalon, and not to the mesencephalon.

In reply to this the present writer points out that the homologies of all the other parts of the brain in Teleostei may be deduced from the position of the pineal gland, the infundibulum, and the ganglion of origin of the oculomotorius.

From this line of argument he maintains that the tecta lobi optici correspond to the anterior pair of the corpora quadrigemina, and consequently belong to the mesencephalon, and not to the thalamencephalon. Finally he remarks that the brain in Teleostei would not be in accordance with the remainder of their organisation, if all the parts of a mammalian cerebrum could be distinguished in it, even in a comparatively rudimentary state as is maintained by Fritsch.

III. "On the Spectrum of Carbon." By G. D. Liveing, M.A., F.R.S., Professor of Chemistry, and J. Dewar, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received February 23, 1882.

The spectroscopic investigations we have communicated to the Society "On the Reversals of the Lines of Metallic Vapours," have

* "Unters. ü. d. feineren Bau des Fischgehirn." Berlin, 1878.

† "Primäres Vorderhirn," *loc. cit.*

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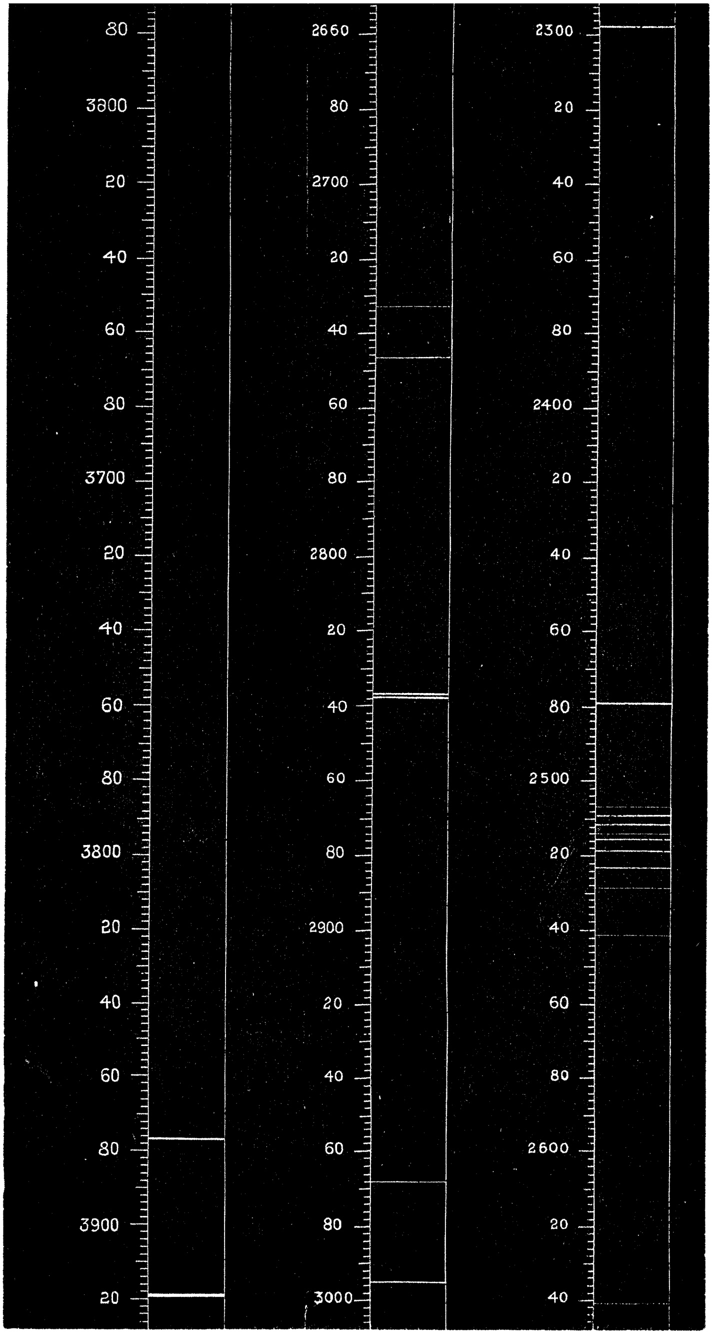
shown the importance of a thorough and accurate knowledge of the ultra-violet spectra of the elements, for it is in the lines of short wave-length as a rule that the greatest emissive power is manifested, and they are therefore most readily reversed. Thus we have succeeded in reversing upwards of 100 lines in the ultra-violet spectrum of iron ("Proc. Roy. Soc.," vol. 32, p. 404). The necessity for accurate data in regard to this region of the spectrum led us to make a long study of the spectrum of magnesium, and the results of this investigation appeared in the volume of the "Proc. Roy. Soc." just cited. Having had occasion to examine the origin of the different fluted spectra of carbon, it became apparent that a complete knowledge of the relations of these spectra to the simple spectrum of the element could only be reached by the help of a complete record of the line spectrum. Ångström and Thalén, in their memoir "On the Spectra of the Metalloids" (Nova Acta Reg. Soc. Upsal., Ser. iii, vol. ix), give a map and table of wave-lengths of the lines due to carbon in the visible part of the spectrum, as distinguished from the fluted spectra given by compounds of carbon, namely, carbonic oxide, cyanogen, and acetylene. These lines, they state, always appeared when very powerful induction sparks were passed through the vapour of any compound of carbon, or between carbon electrodes. This line spectrum is remarkable for simplicity, consisting of eleven lines, of which the single line in the yellow, followed by a triple group in the green, and a very strong line in the blue, recall vividly the spectrum of magnesium; and as we know two modifications of the spectrum of magnesium which seem to be due respectively to the oxide and a hydride, the parallel between the behaviour of the two elements is the more striking. The plates of the ultra-violet spectra of the metals by the late Professor W. A. Miller ("Phil. Trans.," 1864) include plates of the spark taken between metallic electrodes in different compounds of carbon, which show with sufficient clearness that there are some five groups of lines in the ultra-violet spectrum of this element. In the observations here described we have preferred taking intense induction sparks between pure graphite poles in different gases.

The accompanying figure represents the ultra-violet spectrum of carbon to a scale of wave-lengths within the range of the rays transmitted through calcite. The lines figured have been observed in photographs of the spark of a large induction coil, having a large Leyden jar in connexion with the secondary coil, between poles of purified graphite in air, carbonic acid gas, hydrogen, and coal-gas. The same lines have been observed in photographs of the spark between iron, and between aluminium poles in carbonic acid gas. By comparing the photographs taken under these different circumstances, we have, we believe, eliminated the air lines, which are numerous and strong in the region between H and T, and will form the subject of a

Ultra-violet Spectrum of Carbon.



future communication, and also the metallic lines which graphite, purified with the utmost care, still exhibited.

The graphite was purified by being stirred in fine powder into fused potash, and subsequent treatment with aqua regia, by prolonged ignition in a current of chlorine, and by treatment with hydrofluoric acid. The well washed powder was afterwards compressed into blocks by hydraulic pressure between platinum plates, and from these blocks the electrodes employed were cut. Notwithstanding the purification the photographs of the spark between these electrodes still showed very distinctly lines of magnesium and iron. This fact shows the extreme difficulty of getting rid of all impurity, and the caution which is requisite in any reasoning depending on the assumption of chemical purity in the materials employed. It is very possible that the magnesium and even the iron in this case may have been due to oxides of those metals in the floating dust of the laboratory, which we know always contains sodium compounds, and which at Cambridge, where the water, soil, and bricks contain sensible quantities of lithium, almost always shows traces of that element.

The wave-lengths of the strongest carbon lines were determined by means of a Rutherford diffraction grating having 17,296 lines to the inch. The measures were made in the following way: The collimator and telescope of the goniometer were first centred by the instrument maker's marks. The telescope was then more carefully adjusted for centre by directing it on to a distant mark, taking the reading of the circle, turning the arm carrying the telescope through 180° and reversing the telescope, whereby the mark was again brought into the field of view, and adjustments were then made until the mark had the same position on the cross-wires in both positions of the telescope. The grating was next placed in position, and, after adjustment to the vertical plane was brought very nearly at right angles to the axis of the collimator by turning it until the sodium D lines in the spectra of the second order were observed to fall at equal distances on either side of the collimator. The small photographic slide, containing the sensitive plate, fitted the telescope in place of the eye-piece, and so could easily be turned about an axis coincident, or nearly so, with the optic axis of the telescope. In taking a measurement of the position of a line the approximate wave-length was first found by interpolating between the nearest cadmium or other lines of known wave-length in photographs taken with calcite prisms. The telescope was then set to the angle corresponding to this approximate wave-length for the spectrum of the fourth order. The lower half of the slit was closed by a shutter, and the photographic slide having been adjusted for level, the plate was exposed to the light which came through the upper half of the slit, and gave an image of the lines in the lower half of the field. When this exposure was completed, the photographic

slide was turned round through 180° about the axis of the telescope, so as to bring to the top that part of the sensitive plate which had been before lowest. It was then exposed a second time, and thus two images of the same line were impressed on the plate, which were necessarily at equal distances on either side of the point where the axis of the telescope met the plate. By a subsequent measurement with a micrometer under a microscope of the distance between the two images, and the conversion of this distance into angular measure, a correction was found, which was added to, or subtracted from, the reading of the circle to get the exact deviation of the ray producing the line under observation. Another photograph of the same line was next taken in the same way as before, except that the telescope was placed at the corresponding angle on the other side of the collimator. From the two angles thus found, the wave-length of the line was calculated. The process was repeated three or four times for each line, and the mean wave-length thus found for carbon lines were 2296·5, 2478·3, 2509·0, 2511·9, 2836·3, and 2837·2. The numbers deduced from the different photographs of the same line differed from one another in the last figure only, so that we are justified in assuming the first four figures to be accurate in each case. The wave-lengths of the remaining lines were obtained by interpolation from measures of photographs taken with a train of two calcite prisms of 30° each, and one of 60°, on which the iron as well as the carbon lines were shown. The wave-lengths of the iron lines used in the interpolations were deduced from photographs taken with the grating in the same way as that above described for the carbon lines. The wave-lengths thus found for the remaining carbon lines are given in the table below.

In taking the photographs of the spark, the induction coil was sometimes worked by a De Meritens magneto-electric machine, and in that case the stream of sparks was not only extremely brilliant, but produced a deafening roar. Notwithstanding this character of the spark, the photographs, when the spark was taken in air, between poles of purified graphite, showed, besides the carbon lines above described, the set of six cyanogen flutings in the blue very distinctly, and those between K and L, and those near N, strongly developed. On the other hand, when the spark was taken in carbonic acid gas, these flutings almost entirely disappeared, and would no doubt have disappeared entirely, if the last traces of air had been removed from the apparatus.

Table of Carbon Lines.

Authors.	Colour.	Wave-length.	Intensity.
Ångström and Thalén...	Red....	6583·0	2
		6577·5	1
	Orange .	5694·1	4
		5660·9	4
		5646·5	3
		5638·6	5
	Yellow....	5379·0	6
	Green ..	5150·5	4
		5144·2	3
		5133·0	5
	Indigo....	4266·0	1, diffuse
Liveing and Dewar.....	Ultra-violet...	3919·3	2, diffuse
		3876·5	4, "
		2995·0	4, very diffuse
		2968·0	5, " "
		2837·2	2
		2836·3	2
		2746·5	3, very diffuse
		2733·2	6, " "
		2640·7	4, " "
		2541·5	6
		2528·2	5
		2523·6	5
		2518·7	5
		2515·8	4
		2514·0	5
		2511·9	2
		2509·0	3
		2506·6	5
		2478·3	1
		2296·5	3

Spectrum of Incandescent Carbon Filaments.

We have also examined the spectrum of Swan's incandescent lamps. So long as the carbon thread is unbroken, it emits a continuous spectrum, on which neither bright nor dark lines are visible. By gradually increasing the number of cells in the battery, until the thread gave way, we found at the instant of fracture, for a small fraction of a second only, that a set of flutings in the green appeared. In some of those lamps we observed, when the current was nearly as much as the carbon thread would bear without rupture, that a sort of flame appeared in the lamp. On examining the spectrum of this flame, it gave the flutings of carbonic oxide very distinctly, and we made sure that they were those of carbonic oxide, and not those of hydrocarbons, by comparison with the bands of a Bunsen burner. Closer examination showed that this flame was strongest about the junction of the carbon thread with one of the conducting wires, and

that on reversing the current, it shifted from one wire to the other, and the wire about which it appeared was always the positive electrode. In fact, the flame was the glow of the positive pole attending a discharge in rarefied gas; when the resistance of the carbon thread became too great in proportion to the intensity of the current, the discharge began to occur through the rarefied atmosphere within the envelope of the lamp. The spectrum showed that this atmosphere contained carbonic oxide.

By interposing different flames between the incandescent lamp and the slit of the spectroscope, we have been able to make some comparisons of the probable temperatures of the flames and filament. For this purpose a lens of 3 inches focal length was placed 6 inches in front of the slit, and an image of a horizontal part of the incandescent carbon thread formed by it across the (vertical) slit. The appearance in the field of view of the spectroscope was a narrow continuous spectrum extending all across the field. When a flame was interposed between the lens and the slit, the bright lines of the flame were seen above and below the narrow continuous spectrum, and in some cases were continued across it, or were seen reversed upon it. When the flame was that of a Bunsen burner in which was a platinum wire with sodium carbonate, the yellow sodium lines were seen bright above and below the continuous spectrum of the carbon thread, but reversed where they crossed it. When lithium was substituted for sodium in the flame, the red lithium line was also seen bright above and below the continuous spectrum, but reversed where it crossed it. When an oxyhydrogen jet was substituted for the Bunsen burner, and sodium carbonate held in it, the yellow sodium lines were not only bright above and below the continuous spectrum of the carbon, but showed as bright lines where they crossed it, in fact they were conspicuously brighter than the carbon. When coal-gas was substituted for hydrogen in the jet, the same appearance presented itself, only the sodium lines were not so much brighter than the carbon as they were before. Fifty Grove's cells were used with the incandescent lamp, which were as many as could be used without danger of rupturing the threads. When barium chloride was held in the hydrogen flame fed with only a little oxygen, the bright green line of barium (wave-length 5534) was well seen above and below the continuous spectrum, but could not be traced either bright or dark across it. When a flame of cyanogen burning in air was interposed, the bright bands of that flame could be seen above and below the continuous spectrum, but could not be traced either bright or dark across it. When sodium carbonate was held in this flame the yellow sodium lines were seen feebly reversed where they crossed the spectrum of the incandescent lamp. We infer from these experiments that the emissive power of the carbon thread for light of the refrangibility of the D lines is nearly

balanced by that of sodium at the temperature of the flame of cyanogen burning in air, but is sensibly less than that of sodium, at the temperature of a jet of coal-gas and oxygen, much less than that of sodium in the oxyhydrogen jet. This seems to render it probable that the temperature of the incandescent thread is not far different from that of a cyanogen flame burning in air (or rather the temperature it conveys to the sodium in it), but is less than that of an oxyhydrogen flame, though this does not necessarily follow from the experiments, inasmuch as the radiation of the sodium is so much more limited as to range than that of the carbon. When a Bunsen burner or a gas blowpipe flame was interposed between the lens and slit, no reversal of the hydrocarbon bands could be seen. When magnesium was burnt between the lens and slit, the magnesium lines (*b*) were seen bright, eclipsing the carbon. Possibly the smoke of magnesia may have considerably helped to eclipse the light of the carbon.

IV. "Preliminary Report to the Solar Physics Committee on a Comparison for Two Years between the Diurnal Ranges of Magnetic Declination as recorded at the Kew Observatory, and the Diurnal Ranges of Atmospheric Temperature as recorded at the Observatories of Stonyhurst, Kew, and Falmouth." By BALFOUR STEWART, LL.D., F.R.S., Professor of Physics at Owens College, Manchester. Communicated to the Royal Society by permission of the Solar Physics Committee. Received January 25, 1882.

1. In a paper communicated to this Society, and published in its "Proceedings" (vol. 32, p. 406), evidence was brought forward tending to show that what may be termed declination-range weather takes 1·6 days to pass from Toronto to Kew; that is, the same phase occurs 1·6 days later at Kew than at Toronto. And in a previous paper (*op. cit.*, vol. 29, p. 308) evidence was brought forward tending to show that temperature-range weather takes about 8 days to pass between these two places.

In this last-mentioned paper an attempt was likewise made to show that there is a similarity between magnetical and meteorological changes, and that both are due to the sun. This result has been confirmed by subsequent discussion, and there seems reason to suppose that in America both magnetical and meteorological changes follow very quickly after the solar changes which produce them.

Ultra-violet Spectrum of Carbon.