It is unlikely that better conditions exist anywhere than in the region above referred to. Some of the waters are land-locked, some open to the ocean; the great variety in the range of the tide, tending to magnify the undulations where the range is great, and leaving scarcely anything else but these undulations and the effect of storm disturbance, where the tide is flat; the completeness of the meteorological data and the well-charted storm tracks, furnish ample material for comparison. The investigation has not yet been taken up by this Survey, which has to be carried on with so little means and assistance as to confine it at present to the direct practical issues in the preparation of tide-tables, &c. But where such good material exists, it is very unfortunate that descriptions of the phenomena from a few illustrations should be given as an average account of their characteristics, or that conclusions should be founded upon too narrow and incomplete a basis.

W. BELL DAWSON,
Engineer-in-Charge of Tidal Survey.

Ottawa, February 10.

MR. DAWSON characterises my letter as "misleading," and yet, in the course of his own letter, quite neglects to point to an incorrect statement in mine. This is certainly unfortunate.

To show how little Mr. Dawson's remarks touch the substance of my letter, permit me to briefly re-state my position. (1) The oscillations are regular where the basin is fairly regular. This is not questioned by Mr. Dawson, and, as regards the Bay of Fundy, it is amply confirmed by my own observations and the records of Mr. Dawson's department. (2) The oscillations are of irregular period in markedly irregular basins, such as the Gulf of St. Lawrence. This is also not questioned by Mr. Dawson. It is founded on records of four days each from seven different points on the Gulf of St. Lawrence (see the Tidal Report referred to by Mr. Dawson and quoted in my previous letter). Mr. Dawson's only criticism is that he has many other records from the same places; but he does not tell us whether they contradict the published ones. It would certainly be surprising if they did. (3) The period is determined by the dimensions of the basin, and can be calculated from those dimensions, as I have tried to show. (4) The cause of the initial disturbance is probably atmospheric. This point is discussed by Mr. Napier Denison in a short but valuable paper that reached me after my first letter was published. Mr. Denison confines his remarks to the cause of the initial disturbance.

That the period of these oscillations should be determined by the atmosphere seems to me quite incredible. It is surely sufficient refutation that, within a radius of twenty miles from St. John, we have three points at which the regular periods are 35 seconds, 12½ minutes, and 43 minutes respectively, and at one of these points the 35-second and 43-minute oscillations coexist.

Perhaps I have misunderstood Mr. Dawson. If his purpose was to call attention to the valuable materials being gathered by the Canadian Tidal Survey, which Mr. Dawson directs, then I must express my hearty approval, and add the hope that the excellent work may continue and receive efficient support. May I add that my interest is not that of a casual visitor to St. John (as implied by Mr. Dawson), but of a Canadian, most of whose life was passed in St. John? A. WILMER DUFF.

Purdue University, Lafayette, Ind., U.S.A.

The Natural Prey of the Lion.

JEAN BAPTISTE TAVERNIER, in his "Travels in India" (translated by V. Ball, 1889, vol. ii. p. 397), mentions a case similar to what Mr. Crawshay describes under this heading in your last number (p. 558). "At a distance of two or three leagues from the fort [at the Cape], the Dutch found a dead lion which had four porcupine's quills in its body which had penetrated the flesh three-fourths of their length. It was accordingly concluded that the porcupine had killed the lion. The skin is still kept with the spines sticking in the foot." Thereon it is noted by the English translator that "numerous cases are recorded of tigers having died in India from this cause, and also of occasionally having been found when shot to have porcupine's quills sticking in them." The old Chinese motto, "*the hedgehog defeats the tiger*, and the serpent stops the leopard" (in Liu Ngan, "Hwui-nan-tsze," second century B.C.), is probably founded on observations allied to these. KUMAGUSU MINAKATA.

7 Effie Road, Walham Green, S.W., April 15.

THE PRESENT STANDPOINT IN SPECTRUM ANALYSIS.

IN a former article I referred to some of the difficulties encountered by the earlier researchers in spectrum analysis. In the present one I propose to pass over the history of nearly twenty years' work with all its attendant doubts and difficulties, and deal with what that work has brought us, a perfect harmony between laboratory, solar and stellar phenomena.

It has been proved beyond all question that not only are both fluted (or channelled-space) spectra and line spectra visible in the case of most of the elements, but that many of the metallic elements with which I shall have to deal in the sequel have at least two sets of lines accompanying, if not resulting from, the action of widely differing temperatures.

It is important to mention that the different chemical elements behave very differently in regard to the action of heat and electricity upon them as we pass from the solid to the liquid and vaporous forms; that is, the two different forms of energy are apt to behave very differently, the permanent gases as opposed to the elements which generally exist in the solid form is the first differentiation, the elements of low atomic weights and low melting point as opposed to the rest, is the second.

In the cases in which heat-energy can go so far, we first get an increase in the free path of the molecules, and ultimately the latter are made to vibrate.

In the case of electricity, on the other hand, increase of free path is scarcely involved, and hence we may have effects similar to those produced by high temperature, with scarcely perceptible effects of heat in the ordinary sense.

Conversing on this subject with my friend Clifford, many years ago, we came to the conclusion that the energy imparted to a molecule might cause (1) an extension of free path; (2) a rotation, and (3) a vibration. To get concrete images of these effects we spoke of *path-heat*, *spin-heat*, and *wobble-heat*. The facts seemed to show that heat energy had no effect in producing line-spectra until the two first results had been obtained, and, further, that in all gases and many metals it had no effect in producing vibrations; while, on the other hand, electrical energy generally acted as if it began at the third stage, and is effective in the case of every chemical substance without exception.

However this may be, we now know that many elements present changes at several widely differing stages of heat. The line spectra of elements like sodium, lithium, and others may be obtained by the heat of the flame of a spirit lamp, or an ordinary Bunsen's burner, the substance being introduced into the flame by a clean platinum wire twisted into a loop at the end.

This temperature has no effect upon iron and similar metals. To get any special spectral indication from them a higher temperature than that of the Bunsen is required, the blowpipe flame may be resorted to; in this a stream of air is blown through the centre of a flame of coal gas burning at the end of a cylindrical tube.

We get in this way what is called a "flame-spectrum," in which flutings and some lines are seen. In order to obtain the complete line-spectra of some of the less volatile metals, like iron and copper, we are driven to use electrical energy and employ the voltaic current, and (for choice) metallic poles which are so strongly heated by the passage of the current that the vapour of the metal thus experimented on is produced and rendered incandescent.

We may say generally that no amount of heat-energy will render visible the spectra of gases. These are obtained by enclosing the gases in glass tubes and illuminating them by means of an electric current. We may go further and say that the ordinary voltaic current