clear, and to this part of the inquiry Prof. Ewing contributed a most important statement as to the educational value of research as demonstrated by his experience at Cambridge. We may hope that at least after thirty years' debate this matter can be considered settled. In the language of our correspondent, "Since Germany has given to our disadvantage a definite experimental proof of the success of research as an instrument of education, the delegates probably felt that the matter had gone beyond the range of academic discussion."

When once this idea of the proper function of universities is re-established and in full operation, not only at Oxford and Cambridge, but in many other British universities, it may happen that not everybody will agree with Mr. Balfour's comparisons between the old and the new seats of learning.

"I daresay that many of us have looked back with a certain regret, and a certain feeling of shame, to the medieval passion for learning without fee and without reward—with no desire to make the universities stepping-stones to good places or to successful mercantile or industrial undertakings—but with an ideal which made thousands of students from every country in Europe undergo hardships which would be regarded in these softer days as absolutely intolerable, for the sole purpose of seeking, and it might be finding, the great secret of knowledge. We despise, and we perhaps rightly despise, their methods. We know that they were not in touch with the actual realities of the world in which they lived. Yet, after all, we have something to learn from them; and if we in these days could imitate their disinterested passion for knowing and for extending the bounds of knowledge, surely we, with our better methods, and our clearer appreciation of what we can know and what we cannot know, might accomplish things as yet undreamed of. Now, what did they do? They moved from university to university, from Oxford to Paris, from Paris to Padua, from country to country, in order that they might sit at the feet of some great master of learning, some great teacher who might lead their thoughts into undreamed of paths. I hope that in the universities of the future every great teacher will attract to himself from other universities students who may catch his spirit—young men who may be guided by him in the paths of scientific fame; men who may come to him from north or from south."

We agree as to the facts as to the past, but it is not the carelessness and greed of the modern student that are in question, but rather the decadence of our universities, which are no longer seats of learning in the old sense, that is, they do not supply the knowledge most useful to those who attend them in relation to the needs of the time. They are chiefly conducted as playgrounds for the sons of the rich, learning is too little endowed, and great teachers are too little encouraged, especially in the matters in which the modern world is concerned.

If only students of science found at our universities of to-day what students of theology, law, medicine, and *les trois langues*, found in the old time at all universities, that is, perfect teaching, and the endowment of research at the university itself, things might be righted, and, as of old, many fitted for the battle of life would go out into the world to apply their knowledge as did their forerunners, and show neither more

nor less "disinterested passion" than the well paid ecclesiastics, lawyers, and doctors of the past.

It is because the universities of Germany, France, and the United States, aided by wisdom and endowments, conform to the old ideal, while our ancient ones remain as *hauts lycées*, as Matthew Arnold called them, and our modern ones are crippled for want of funds, that the students of both Britain and Greater Britain find an advantage in going abroad to build up their brain power.

It is to be hoped that as a result of the conference the educational federation of the Empire will some day be brought about. It must not be forgotten that the first step in this direction was taken when the Royal Commissioners for the Exhibition of 1851 founded its research scholarships, in which every university in the Empire has a share—a share which it has fully used, and with the best effects. That other similar scholarships should be founded by the different Governments and private individuals may be one of the results of the conference.

Our plea for better brain power for the nation was not lost sight of in the deliberations, and we may fitly conclude by the following quotation from a speech by Mr. Haldane, which brought the discussion to a close.

"To-day we are a step further on towards doing that which, as a people, as the great English-speaking people, we need more than anything else. We have got the splendid energy of our race, we have got the power which is ours, in a unique degree, of adapting ourselves to new conditions, of overcoming difficulties which to others might even seem to be insurmountable, and yet we have been deficient in the capacity of organisation. What we have lacked in this country, somehow, has been the thinking faculty; and it is the work of education to develop the thinking faculty in a nation. And never before was the thinking faculty so much needed as to-day when the weapons which science places in the hands of those who engage in great rivalries of commerce leave those who are without them, however brave, as badly off as were the dervishes of Omdurman against the Maxims of Lord Kitchener."

THE SPECTROSCOPE IN ASTRONOMY.

Problems in Astrophysics. By Agnes M. Clerke. Pp. xvi + 567. (London: A. and C. Black, 1903.) Price 20s. net.

THE triple alliance of astronomy, physics and chemistry has extended the boundaries of each in unexpected directions. Astronomy is no longer a dependency of mathematics, but an independent power having a high place in the hierarchy of the physical sciences; instruments of research in physics have been turned from earth to sky, and chemistry now looks to the stars for evidence as to the distribution and ultimate structure of the elements.

The spectroscope is the chief means by which these new territories have been gained for science and explored, and the photographic plate has not only been its faithful scribe, but has also gained distinction as an astronomical artist. Individually and jointly, the prism and the camera have increased our knowledge of the nature and number of all classes of celestial

objects. The general study of the solar spectrum has given way to investigations of the sun in detail; and spectrum analysis now not only reveals the constitution of the stars, but measures their movements with an exactitude impossible by any other means. The light of nebulae has been shown to be but the manifestation of molar activity having a vastly greater sphere of influence than that suggested by the visible limits; and nebulae themselves, from being regarded as a peculiar class of celestial bodies, have been linked to stars and shown to be the amoebae in a scheme of inorganic evolution.

The story of this development is related by Miss Clerke in the exuberant style with which all readers of astronomical literature are familiar. The first part of her book, occupying about one-third of the whole, is devoted to the sun, and the remainder to sidereal physics. Among the subjects of chapters in the former part are peculiarities of the solar spectrum, the reversing layer, the spectrum of sun-spots, the chromospheric spectrum, the sun's rotation, and the solar cycle. The forty-one chapters of the second part deal with many varieties and characteristics of stars and nebulae, the subjects including helium stars, carbon stars, the spectra of double stars, rotation of the stars, spectroscopic binaries, dark stars, star clusters, nebulous stars, variable nebulae, the nature of nebulae, and the physics of the Milky Way.

For the collection and analysis of contributions to the study of these and other problems in astrophysics, Miss Clerke merits the thanks of astronomers. As is the case with every branch of science in its youth, questions arise much faster than they can be answered, and it requires a fine critical faculty to separate results of transient value from those of significance to scientific progress. The historian has to decide what things matter and what may be neglected when considered from the point of view of their influence upon development; and success is achieved when this power of discernment is combined with insight which enables the relationship to be seen between cause and consequence.

With the best desire in the world to give Miss Clerke credit for her work, we must confess to a feeling that it is not altogether satisfactory. In the first place, the net which she has used in her explorations of astronomical literature is of too fine a mesh, so that she has gathered in results and ideas which ought to have been discarded as being of little value, or immature. Next, as we shall show later, she has not understood the real nature of some of the material collected; and finally, she passes judgment and gives advice on matters which can only be rightly understood by investigators actively engaged in spectroscopic work.

A man who has had a scientific training can quickly grasp the essential points of progress in any branch of natural knowledge if they are brought before his notice, but he will rarely venture on criticism of results, or lay down the lines of further research unless he has a personal and practical acquaintance with the subject. Miss Clerke does not always exercise the same caution, with the result that she sometimes labours the obvious. Her function as an historian is to assimilate and describe, and when she

is exercising her talents in this direction she is at her best. She surveys the work from the point of view of the spectator, and should describe fairly and clearly what she sees, without irritating the men who are doing the work by expressing her opinion upon it or suggesting what course they ought to take next. In other words, she should remember that "Passengers are respectfully requested not to speak to the man at the wheel."

In preparing a statement of the position of fact and theory in any branch of science, great care must be exercised, and not a single assertion should be made without substantial reason for it. A cynic has said that it is a characteristic of women to make rash assertions, and in the absence of contradiction to accept them as true. Miss Clerke is apparently not free from this weakness of her sex. Referring to the line 1474 K she says (p. 117):—"Eclipse-spectrographs do not include it, while they have afforded some other quite unexpected results." An examination of spectrum photographs of the eclipses of 1893, 1896; and 1898 would have shown Miss Clerke that 1474 K is included in all of them. There are other instances in which statements of an *ex cathedra* character are made without a full appreciation of the facts. Thus, the identification of a "dozen and upwards" chromospheric lines in the spectra of krypton and xenon (p. 120) is doubtful, to say the least; and the Stonyhurst origins referred to on p. 187 in connection with the spectrum of γ Cassiopeiæ are in the same case. Again, in the table of nebular lines on p. 477, the line at λ 4122 has a note of interrogation placed after the word helium indicating its origin, though there is practically no doubt that the line is helium λ 4121. Moreover, the line λ 4715, said to be of origin "unknown," is really the helium line λ 4713.

It is in such matters as these that Miss Clerke shows she is not a working spectroscopist possessing an intimate acquaintance with the subjects she describes. The result is that she is led to pass unsound judgments, and to be satisfied with an imperfect record of the facts available. Thus, on p. 48, in considering the relation of the chemistry of the chromosphere to the depth she quotes a paper by Mr. S. A. Mitchell, but makes no reference to the Royal Society report on the 1893 eclipse, where a full discussion of the conditions is given. Again, for evidence of the existence of more than one gas in the solar corona reference is made (p. 131) to a paper by Mr. S. J. Brown, but a note on the discussion of the photographs of the 1898 eclipse, presented to the Royal Society and published in the *Proceedings* (vol. lxvi. p. 189), is not mentioned, though it shows that three groups of lines, indicating three gases, are recognisable in the corona spectrum.

Miss Clerke demurs to the late Prof. Rowland's conclusion that there is no fundamental difference between solar and terrestrial chemistry. *Quantitative, if not qualitative, dissimilarity must,* she believes, "be recognised"; and she instances titanium among other elements which are clearly represented in the solar spectrum, and yet are scarce here. Titanium is more widely distributed than Miss Clerke supposes, but, even if it were extremely rare, her

suggestion as to the relative amounts of this and other elements existing in the sun and earth is misleading. Remembering that nothing is known of the chemical constitution of the earth a few miles below the surface, it is possible that rare elements in the crust may be abundant nearer the centre. The differences between solar chemistry as manifested by the solar spectrum, and terrestrial chemistry as represented by mineralogical knowledge, are therefore only apparent, and Rowland was justified in his remark, "were the whole earth heated to the temperature of the sun, its spectrum would probably resemble that of the sun very closely."

The distinction between spark and arc spectra is not sufficiently recognised, with the result that unsound judgments are sometimes reached. A case of this kind occurs in connection with the discussion of the chromospheric spectrum. The green line of the chromosphere is coincident with one of the members—due to iron—of the triplet known as Kirchhoff 1474 in the Fraunhofer spectrum. Miss Clerke says:—

"Now the chromospheric ray agrees in position with the iron line, which is one of secondary importance; yet it cannot at present be asserted confidently that it really emanates from glowing iron vapour. If it did it should be ordinarily associated with other iron lines, and none have been ascertained to make part of the fundamental chromospheric spectrum."

If the spark spectrum of iron had been considered instead of the arc spectrum, these remarks would, we think, have been modified. The iron line at 1474 K is not of secondary importance in the spark spectrum; indeed, the fundamental chromospheric spectrum consists largely of iron lines—not the ordinary lines of the arc spectrum, but lines such as those at $\lambda\lambda$ 1474 K, 5018, 4924, 4584, and 4233, which are enhanced in relative importance in passing from the arc to the spark.

In connection with the subject of the temperature of the stars, the behaviour of lines of magnesium at different temperatures is referred to. Other conditions being the same, the magnesium line 4352 becomes finer with increase of temperature, while that at 4481 becomes thicker, and this opposite behaviour provides a test of increasing or decreasing temperature. But it is not pointed out that the test must be applied with caution; for the line 4352 in the spectra of hot stars is not due to magnesium, but is really an enhanced line of iron. If 4352 in the hot stars were a magnesium line, then other lines of the same series ought to be present, but they are not.

The chapter on new stars is characteristic of a large part of the book. Details are given of observations of new stars from Nova Aurigæ to Nova Persei, but the record can scarcely be described as complete, and the chief lesson taught by Novæ is overlooked. Many years ago, Sir Norman Lockyer expressed the view that "new stars, whether seen in connection with nebulae or not, are produced by the clash of meteor swarms." When this conclusion was arrived at, few precise observations of the spectra of Novæ were available, but it is not too much to say that visual and photographic inquiries made since then into the phenomena of new stars have substantiated it in a

very remarkable manner. By the meteoritic hypothesis, new stars approximate to nebulae as they fade, until their light at the last stage is indistinguishable from that of a nebula. This association of new stars with nebulae is now an accepted fact, but the consequences have not been so clearly acknowledged. As a new star reverts to the condition of a nebula when it cools, evidently nebulae are not masses of gas at transcendental temperatures. Just as in biology, the course of evolution is traced in the development of the embryo, so we may consider that in its brief life a new star passes in some respects through the various stages which mark the growth and decay of worlds.

The spectroscopic history of Nova Aurigæ was a surprise to astronomers, who regarded the meteoritic interpretation of the phenomena of new stars as a hypothesis of doubtful validity. For, though there might be a difference of opinion as to the meaning of the displacement of the bright and dark lines in the spectrum, there could be none on the fundamental fact that the Nova became a planetary nebula, both visually and spectroscopically, as it sank into obscurity; and this course of events was precisely that previously found to have been exhibited by new stars which had been subjected to spectroscopic analysis. Rarely has hypothesis received such decided confirmation, but Miss Clerke does not even mention the paper in which it is put forward. The history of several new stars is concluded with words to the effect that "the regular cycle had been run through: a planetary nebula replaced the faded star," but there is no reference to the analysis of spectroscopic records before Nova Aurigæ, which showed that the reversion to a nebular type is a common characteristic of new stars.

The case of Nova Persei is of even greater significance from the point of view of cosmogony than that of Nova Aurigæ, for its light revealed the existence of vast areas of dark matter in interstellar space. Miss Clerke describes the vicissitudes through which the object passed, and the apparent expansion of the nebula associated with it. With regard to this phenomenon we read:—

"An explanatory hypothesis of considerable plausibility was hit off independently by Prof. Kapteyn and Mr. W. E. Wilson.¹ It affirms the nebula to have been pre-existent, and to remain unchanged. But since we see it by the unchanged light of the Nova, its various spires and condensations have come successively into view as the flare of the explosion travelled outward in widening circles. Hence an illusory effect of radial expansion was produced, while in point of fact, the temporarily illuminated cosmic folds were as immovable as aligned snow-peaks, in turn set aglow by the setting sun."

In other words, cosmic dust, or meteoritic particles, or dark nebular matter—whatever you care to term it—existed in the part of space in which the new star made its appearance. The fundamental idea of the meteoritic hypothesis is here accepted, and its application to the phenomena of new stars acknowledged. Astronomers have, in fact, been driven to the belief in the existence of sheets or streams of non-luminous matter in space; and dark nebulae, as Prof. Turner has termed them in an article in the *Fortnightly*

¹ NATURE, January 30, 1902.

Review, are no longer considered hypothetical, but as real as dark stars.

A new class of celestial bodies has thus been brought under notice, and Miss Clerke does not sufficiently appreciate its significance. This, however, is a matter of opinion, but surely for the sake of historical completeness she might have mentioned that the association of nebulae with new stars was first put forward in the meteoritic hypothesis. She is careful to give credit in most cases, but in connection with Nova Persei no reference is made to the fact that Sir Norman Lockyer first suggested in these columns that the dark nebula existed before the star appeared. In the issue of December 12, 1901, he wrote:—

"It is impossible to think that the great nebula which has now been photographed while the new star is still in being did not exist there a few months ago; and it is important, further, to remark that the nebulous matter already photographed in the region round the Nova is very probably only a portion of the actual amount of matter existing there, and that if the disturbances continue, more of the remaining portion may become visible."

Here we have a definite statement of the pre-existence of the dark cosmic matter in the neighbourhood of Nova Persei before the new star became visible, but it has been overlooked by Miss Clerke. This is to be regretted because, a few years hence, astronomers will be just as interested in knowing how the idea of dark nebulae passed from hypothesis to demonstration as we are in Bessel's discernment of the existence of dark companions of Sirius and Procyon before these bodies came within the sphere of astronomical discovery.

One other point connected with Novæ is worth mention. In the description of the spectrum of Nova Aurigæ it is stated that "an exceptional feature was the predominance of 'green' helium; D_3 and the rest of the lines belonging to the 'yellow' set were comparatively faint; while λ 4922, λ 5016 and their fundamental λ 6678, shone lustrously." An unnecessary difficulty is raised in the attempt to account for the appearance of these lines in the Nova spectrum; for the first two lines mentioned were really not due to helium, but were enhanced lines of iron at λ 4924 and λ 5018. This identification does not rest solely upon these two lines, for other enhanced lines of iron appeared in the spectrum of the Nova.

Other details upon which there are differences of opinion might be mentioned, but no useful purpose would be served by doing so. In directing attention to the various points referred to in the foregoing remarks, the object has been to show that, though Miss Clerke writes with exceptional facility and grace, she is not an infallible guide, and has a tendency to works of supererogation. Notwithstanding this, we do not hesitate to say that, by writing the record of astrophysics, she has done a great service to astronomers. Her book makes it possible to obtain a view of the chief fields in which astronomical inquiries are now being carried on, and of the achievements which have been reached. To readers interested in the progress of knowledge relating to the sun, stars and nebulae, whether they are laymen, or men of science so deeply engrossed in other investigations that they have not

been able to keep in touch with astronomy, the book will be a revelation. Those who are engaged in the work of astrophysics will be saved many hours of tedious research among scientific books and papers by this chapter from the history of science.

R. A. GREGORY.

THE GERMINAL LAYERS OF THE VERTEBRATA.

Furchung und Keimblattbildung bei Tarsius Spectrum. By A. A. W. Hubrecht. Pp. 115 + plates. (Amsterdam: Müller, 1902.)

EMBRYOLOGISTS will certainly unite to congratulate Prof. Hubrecht on the completion of this memoir. To have obtained and figured a complete series of developmental stages of any animal is in itself no mean achievement, but when this animal is one of the rarest of mammals, procurable only in a distant quarter of the globe, we may well wonder at the persevering patience which has succeeded in overcoming difficulties which, to an ordinary worker, would have been insurmountable.

Tarsius has always been regarded as a member, though a very aberrant member, of the Lemuroidea. The embryological evidence which has now been brought before us is practically conclusive in favour of its removal from this suborder. The placentation is most pronouncedly of the so-called "deciduate" type, while the arrangement of the foetal membranes, with the diminutive yolk-sac, rudimentary allantois, and large extra-embryonic coelomic space, is identical with that found in man and monkeys, but nowhere else.

The placenta, and the important changes leading to the formation of the "Bauchstiel"—so long a puzzle to human embryologists—have already been the subjects of two publications by Prof. Hubrecht. In the present treatise we are introduced to the processes of maturation, fertilisation, segmentation, the histology of the formation of the amnion, and, above all, to the germinal layers.

First to appear are the above-mentioned extra-embryonic coelom and the yolk-sac. The material for the former springs from the posterior end of the blastoderm. In continuity with it is formed the primitive streak in the centre of which is the rudimentary blastopore or neurenteric canal. The mesoblast, however, is also formed from an anterior tract of hypoblast (as frequently in Amniotes) and from a peripheral ring (as described by the author in *Sorex*).

These facts, admirably illustrated by a very complete set of figures, form the basis for some very bold speculations. The germ layers of the Vertebrata have proved a stumbling-block to many an embryologist. The solution of the problem here proposed (due originally to van Beneden, and first expounded in Oxford) is one which cuts all the old ground from under our feet. We are taken back, not to Amphioxus, or even to an Annelid, but to a Coelenterate, and asked to see in the gastrovascular cavity and stomodæum of this, the latest ancestor of all the Vertebrates, the fore-runners of the blastopore and notochord respectively. Such a theory involves the assumption that the