Satisfactory definition is obtained throughout the whole length (43 cm.) of the plate used in the spectrograph camera. In the more refrangible portions of the spectrum Lumière "Sigma" plates were employed, while from λ 4900 to the red end Seed "Gilt Edge 27" plates sensitised by Wallace's formula were used. For comparison the spectrum of the iron arc was photographed alongside the star spectrum.

Six plates of the spectrum of Sirius (λ 4200 to λ 6600), four of the spectrum of Procyon (λ 4200 to λ 4900), and nine plates of the spectrum of Arcturus (λ 4300 to λ 6600) were available for measurement, and the chief object in the study of these spectra has been to test the possibility of detecting any differences of displacement for the different lines, and thereby obtain some idea of the effective pressure in the atmospheres of the stars. In Sirius the number of lines available for measurement was comparatively small; in the case of Procyon and Arcturus the selection of lines was similar to those used in the investigation of similar displacements of the lines in the spectrum of the sun's limb.

The enhanced metallic lines, it will be remembered, show as a class most definitely larger shifts at the sun's limb than the ordinary arc lines. Now in the spectrum of Sirius the enhanced lines form a prominent feature, while the arc lines are few. In Procyon the enhanced lines are less prominent, while the arc lines have become more pronounced. In Arcturus the enhanced lines are almost evanescent, while the arc lines, which are associated with the spectrum of sun-spots, are very strongly developed. Mr. Adams gives a table showing in summary form the main results of the inquiry, from which it is seen that in all cases the enhanced lines show a decided displacement to the red relative to the arc lines. Giving the displacements as radial velocities in kilometres, we may summarise the results as:—

Sirius: Enhanced—Arc Lines = +0·90 km. = +0·014 A
Procyon: ,, ,, ,, = +0·58 ,, = +0·009
Arcturus: ,, ,, ,, = +0·08 ,, = +0·001

The behaviour of the prominent lines in Arcturus is so definite that a special discussion is given of them. A large proportion of the lines of titanium, vanadium, and calcium are greatly strengthened, the enhanced lines decidedly weakened, and those of iron and chromium either strengthened or weakened according to their temperature gradation. The lines of nickel appear to be more prominent in the star spectrum than in sun-spots. The following table summarises this discussion:—

Element	Displacement Å	Equivalent Velocity km.
H	−0·020	−1·2
Ca	−0·017	−0·70
Mg	−0·011	−0·68
V	−0·006	−0·24
Ti	−0·006	−0·23
Ni	−0·006	−0·22
Fe	+0·006	+0·25

The shifts evidently suggest definite grouping of similar elements. The iron lines show a shift towards the red compared with all the other elements examined.

Such is the material Mr. Adams provides for his investigations. In the absence of any other known probable cause, he considers pressure as the principal agent causing these systematic displacements in stellar spectra. The laboratory experimental results of Humphreys and others gave as an average shift for the arc lines of iron 0·0025 Å per atmosphere of pressure. At the sun's limb the enhanced lines in the more refrangible portion of the spectrum were found to be shifted approximately 50 per cent. more than the arc lines, and recent work by Mr. Gale on the spectrum of titanium indicates that the enhanced lines of this substance are also shifted more than the arc lines at the same pressure. Assuming, then, that a similar relationship exists between the enhanced and arc lines of other elements, this affords a means of estimating the gravitational pressures in the atmospheres of stars the spectra of which show these displacements. Thus, as seen in the table quoted above, the enhanced lines in the spectrum of Sirius are shifted towards the red relative to the arc lines by 0·014 Å. This would correspond to a pressure of 12 atmospheres in excess of that existing in the sun's reversing layer. Similar reasoning in the case of Procyon indicates a pressure of 7 atmospheres over that of the sun's reversing layer. These results appear to be in accord with the modern view of regarding stars of the Sirian type as possessing no true photosphere, being simply a mass of gas increasing in density towards the centre without any surface of discontinuity or condensation. In such a star the light coming from great depths would most probably be visible from outside, and indications of great pressure would then be expected. In Procyon the spectrum indicates a transition stage between Sirius and the sun, and the pressure is shown intermediate also. It should be noted here, however, that one of the most important cases investigated by Humphreys in his work on pressure effects is directly opposed to the above conclusions. He found that in the case of calcium the blue *g* line was shifted by pressure about *twice* as much as the H and K violet lines. Now the behaviour of these lines in the laboratory, and also in the spectrum of the solar chromosphere, indicates that H and K are typical *enhanced* lines, while 4226 (*g*) is a very typical *arc* line. The differential pressure effect on the enhanced and arc lines of strontium was exactly similar to that of calcium, viz. the enhanced lines were shifted *less* than the arc lines. Unfortunately for this discussion, Humphreys only employed the arc spectrum in his pressure investigation, so that the general behaviour of the enhanced lines of other substances than calcium and strontium cannot be inferred from his results.

Passing on to the conditions of pressure in Arcturus, it is pointed out that the facts indicate the existence of a well-formed photosphere, the light from which proceeds from relatively low-pressure areas at moderate depths. The results for the lines of different elements indicated in the table are similar to those found for the solar lines. Thus in the sun hydrogen rises to very great heights, calcium and magnesium also being high-level substances Titanium is also relatively high-level, but iron is distinctly a low-level element. In Arcturus the displacements indicate exactly such an arrangement, and it is thus concluded that the lines of H, Ca, Mg, Ti, &c., are subject to less pressure than those of iron, and therefore that the gases producing them lie at a higher average level.

CHARLES P. BUTLER.

RECENT INVESTIGATIONS ON SOIL FERTILITY.

FOR some years past the United States Department of Agriculture Bureau of Soils has maintained that infertility might, and not unfrequently does, arise from the presence in the soil of toxic organic substances that have been excreted from the roots of plants. This view has been opposed on two grounds: it is not evident that plants do normally excrete poisonous substances; and if such substances are present there is no proof that they would act as poisons in the soil, which possesses a remarkable power of withdrawing dissolved substances from solution. Not long ago Scheiner isolated dihydroxystearic acid from a considerable number of unproductive soils, and now, in conjunction with J. J. Skinner,[1] he has examined its behaviour to plants in water cultures. In all cases its effect was toxic, but the toxicity was much reduced when fertilisers were added to the solution, and was at a minimum when the fertilising constituents were present in the ratio most favourable to plant growth. Several incidental questions were also cleared up dealing with water cultures—perhaps the most difficult of all experiments to interpret—and the paper contains a great number of data bearing on the subject. The behaviour of this acid in the soil is not touched upon, and very wisely no attempt is made to argue from a water culture to a soil. It is, however, a distinct step in advance that an acid has been isolated from certain soils and identified, and shown to be poisonous in water culture. The results may well be connected with the known fact that, in absence of lime, soil becomes acid and loses fertility, which can only be restored by addition of lime or chalk.

[1] Bulletin 70, Bureau of Soils, U.S. Department of Agriculture.

So great is the part played by bacteria in determining fertility, that a great amount of attention is being paid in most soil laboratories to their various actions. The fixation of nitrogen is of perennial fascination, and is still far from being solved. Certain bacteria, notably azotobacter, can take up gaseous nitrogen and synthesise protein, nuclein, &c., without any materials save only sugar and various mineral salts. The organisms occur in most soils, and it is only necessary to inoculate small quantities of soil into a solution containing the sugar, phosphates, potassium and other salts, but no nitrogen compounds, for development to take place and nitrogen fixation to occur. The chemistry of the process is unknown; investigation, so far, has been confined almost entirely to morphological work and to the effect of various conditions on the process. Messrs. C. Hoffmann and B. W. Hammer, of the University of Wisconsin Agricultural Experiment Station, have recently (Research Bulletin 12) repeated and extended some of these observations. They find the best sugars are mannite and lactose, but it is not desirable to have too much. Similarly, there is no advantage in having too much calcium carbonate, although some is needed. In one respect these authors differ from previous investigators; on analysing the dry azotobacter cells they obtained a protein content of 17·75 per cent. only, against 80 per cent. found by Gerlach and Vogel and 70·6 per cent. by Stoklasa. The cause of the difference is not clear, but may perhaps be ascribed to the slime that invariably surrounds the organism without being an integral part of it, and that is only removed with great difficulty.

How far azotobacter is active in the soil is difficult to determine, because there is an opposite process, the liberation of gaseous nitrogen from protein, and also, under anærobic conditions, from nitrates, also brought about by bacteria. But it has been shown by Koch that the addition of sugar to soil some months before the seed was sown led to an increase in crop by increasing nitrogen fixation, although if applied direct to the crop it produced harmful results. These facts are attracting much attention in sugar-producing countries, and it has been shown that waste molasses, which cannot profitably be sold, gives useful increases in crop when applied as manure some weeks before planting, especially on light soils. S. S. Peck, of the Hawaiian Sugar Planters' Experiment Station (Bulletin 34), has studied the two changes, nitrogen fixation and denitrification, and confirms the general results already obtained; molasses applied before planting stimulates nitrogen fixation, but applied to the growing plant it does harm by causing loss of nitrate or diminished nitrification.

He also confirms some recent work of Russell and Hutchinson, and finds that numbers of protozoa harmful to bacteria occur in soil—he found amœbæ, paramecium, and others—all of which can be destroyed by moderate heat or antiseptics like carbon disulphide. Partial sterilisation of the soil is being studied in several directions. *The Journal of Agriculture of South Australia* states that farmers there have long recognised the advantage of burning the stubbles, and thus heating the soil; investigations are in hand at the Roseworthy Agricultural College to study the problem from this new point of view. An apparatus for soil sterilisation suitable for gardeners is described in *The Journal of the Department of Agriculture of Victoria*, which is similar in principle to some that are working in England. *The Scientific American* recently gave an account of methods proposed in the United States.

Although nitrates are invaluable in the soil, an excess is injurious, because it causes plasmolysis. Dr. Headden, of the Colorado Agricultural College Experiment Station (Bulletins 155 and 160), reports analyses of soils in Colorado containing such excessive amounts of nitrates that they were sterile. He thinks their formation can be explained only as due to bacteria; he supposed that nitrogen fixation has gone on to an excessive degree, and has thus led to disastrous consequences. Further work on these soils will be awaited with interest.

The factors determining soil fertility are slowly being disentangled, but they are far from being fully known, and therefore investigations of cases of infertility are of considerable scientific interest, besides being of technical importance. Such a case is afforded by the scouring pastures of Somerset, now being studied by C. T. Gimingham, of the University of Bristol. Pastures in certain districts of the Lower Lias formation cause diarrhœa or "scouring" in cattle fed on them. No obvious explanation is forthcoming, no poisonous weeds are found, nor does the provision of a pure water supply obviate the trouble. Mr. Gimingham has, in *The Journal of the Board of Agriculture* (No. 7), collected the main facts, and adduces strong evidence to show that the physical condition of the soil is the determining factor, the peculiar conditions obtaining on the Lower Lias, but not on the adjacent alluvium and Inferior Oolite, being favourable to the factor actually causing the disease. Experimental work on this subject is necessarily slow and tedious, but, in view of its importance, it is much to be hoped that Mr. Gimingham will be able to continue the work on the sound lines on which he has begun.

The phenomena of flocculation and deflocculation in soils have been much investigated, but are far from being worked out. E. E. Free has recently summarised (Journal of the Franklin Institute) the present position of our knowledge, and has shown that a marked influence is exercised by impurities present in the water in which the suspensions are made for experimental purposes. He considers it probable that in absolutely pure water only a medium degree of permanence would be attained. In his view, any material can be suspended in water, flocculated, and deflocculated, if it can be got in a sufficiently fine state.

E. J. RUSSELL.

MUSEUM WORK IN INDIA AND AFRICA.

ACCORDING to the report of the Natural History Section, the year 1909–10 was an important one in the development of the Indian Museum, Calcutta, as it witnessed not only a reorganisation of the staff of that section, but likewise the passing of an Act to give greater independence to the constituent sections in the matter of scientific and educational work, and also to permit the respective chiefs of the same to become *ex officio* members of the board of trustees. As a result of the new regulations, it will be possible to separate the archæological from the zoological section, and to place the former under the control of the director of the Archæological Survey. Among the additions during the year, attention is directed to the cast of a susu, or river-dolphin, from the Hughli.

The report on the fishes collected by the *Golden Crown* is continued, by Messrs. Annandale and Jenkins, in No. 1 of the third volume of the Memoirs of the Indian Museum, these contributions including a supplementary note on the rays, together with accounts of the Plectognathi, Pediculati, and flat-fishes. As the collection of sharks made by the *Golden Crown* was relatively small, the consideration of that group is postponed. The teleostean collection, on the other hand, is so extensive that its description in an adequate manner will practically mean a revolution in our ideas of the Indian marine fish-fauna. In the present contribution three small and compact groups, to which the additions are comparatively few, have been selected for treatment.

From among nine papers on various groups of invertebrates in the fourth part of vol. v. of the Records of the Indian Museum it must suffice to refer to some interesting information, by Messrs. Henderson and Mathai, on the occurrence of dimorphism in certain fresh-water prawns of the genus Palæmon. In many, if not all, the species two forms of adult males occur, namely, a normal type of relatively large size, with well-developed nipping-claws, and a generally smaller type, with the same claws no bigger than in females. Among certain other decapods in which a similar dimorphism obtains, the two phases are recurrent, and severally represent the breeding and non-breeding conditions; but, so far as the authors of the paper could ascertain, this does not appear to be the case with the Indian Palæmons.

The classification of the anopheline mosquitoes of India forms the subject of No. 5 (it may be noted that "part" and "No." are respectively used in the two issues) of vol. iv. of the serial last quoted. The changes proposed are of a radical character, the author, Major S. P. James, refusing to admit that any of the species are referable to the typical Anopheles. The Indian members of the group