extension of the spectroscopic field into the ultra-violet and infra-red. In the old tables the limits of the spectra were practically 394 and 670, whereas in the new ones the lines range from 204 to 770. Spectroscopy has also advanced in another direction. It was formerly believed that each substance had its own characteristic spectrum, from which there was no departure; but subsequent researches have shown that the spectrum does not entirely depend upon the substance under examination, but also upon the conditions of temperature and pressure. In the old tables, for example, only one spectrum of oxygen was recorded, but now no less than three are given. Hydrogen, again, has now two spectra recorded, and nitrogen three, including Hasselberg's important observations.

The wave-lengths given in Ångström's "Spectre Normal du Soleil," with a few small corrections, are still taken as the standards for reduction. The tables printed in the Reports of the British Association Committee form the basis of the new edition, but there are also many important additions. One new feature is the addition of a column giving oscillation frequencies, in number of waves per centimetre *in vacuo*, which will no doubt be appreciated most by investigators of the molecular origin of spectra. Tables of the spectra of various compounds, such as ammonia, alumina, and other oxides, chlorides, iodides, &c., and water, are also given. The different substances are arranged alphabetically as in the old edition, and at the head of each there are full references to books and memoirs. The introductory matter has also been considerably expanded, and now forms an excellent guide to spectroscopic scales and methods of mapping. The use of a lens to throw an image of the light source on to the slit, a method which has yielded many valuable results, is, however, unfortunately omitted. The book will be heartily welcomed by all who are engaged in spectroscopic work, and no recommendation of ours is necessary.

A Text-book on Steam and Steam-Engines. By Prof. Andrew Jamieson, M.Inst.C.E. (London: Chas. Griffin and Co., 1889.)

WE welcome with pleasure the fifth edition of this work. Few engineering text-books are intelligible to the average student. Many writers, in dealing with even the simplest engine or mechanical contrivance, completely fog the reader's understanding by the undue use of mathematics and abstruse formulæ. The volume before us is the best yet published for use in the engineering classes at our schools and colleges. Prof. Jamieson has treated the subject in a sensible and useful manner; his examples are worked out as simply as possible; and the descriptions throughout the work are those of a practical man who knows his business.

The new edition contains many extensive and important additions both to the text and illustrations. The chapter on locomotives has been considerably enlarged and improved. An express-engine built by Messrs. Dubs and Co., the eminent Glasgow locomotive builders, is taken as an example, and many well-executed scale-drawings are given as illustrations. Even with these additions the chapter does not do justice to this important branch of engineering, and Prof. Jamieson must not overlook the fact that he has many locomotive engineer apprentices attending his Glasgow classes. The few paragraphs on the compound locomotive are decidedly weak. Mr. Webb's compound locomotive "The Experiment" is excellent ancient history, no doubt; but why not describe the more recent Webb compounds, or, better still, the Worsdell and Von Borries two-cylinder compounds, now doing such good work on the North-Eastern and many foreign railways?

N. J. L.

LETTERS TO THE EDITOR.

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An Unusual Geological Sequence.

IN a late expedition to the north-west coast I have come upon evidence of a fact which was quite new to me—namely, that the well-known Cambrian red sandstones of Ross and Sutherland do not always rest upon the Archæan gneiss, but occasionally on dark blue stratified rocks with which the sandstones are perfectly conformable. For many years I have been familiar with the ordinary sequence, according to which the Cambrian or "Torridon" sandstones rest unconformably on the Archæan gneiss with nothing interposed between them. Nowhere in Sutherland, or in Loch Torridon, so far as I have observed, is there any variation in this order, and I have stood on some hills in Sutherland where the Cambrian sandstones are represented by only a few remaining cakes of conglomerate which lie bedded almost horizontally upon highly unconformable gneissic strata. I was therefore much surprised to see in a little creek on the eastern shore of the Island of Rāāsay, a low precipice of the red sandstone terminating in conformable beds of a rock of very dark colour, and with a texture but little crystalline. The sudden and violent change of colour at once attracted my attention, and on landing and obtaining specimens I found there could be no mistake that the Cambrian sandstones here rest upon some older rock totally different in mineral character from the Archæan gneiss, and equally different from themselves.

Pursuing this (to me) discovery, I examined the eastern face of the same island, where its precipices include fine escarpments both of the Secondary and of the older rocks. There, at one point, I found the same unusual sequence beautifully distinct. The sandstones are represented by a bed of strong conglomerate, and this bed rests conformably upon well stratified rocks of a blue, or dark blackish-blue colour, with a fracture far less crystalline than most of our Silurian slates on the mainland of Argyllshire.

Following up the same clue, I found that on the western shores of the Island of Scalpa, these blue rocks underlie in great thickness the red sandstones which form the bulk of the island, and which are exclusively seen by all who approach it from the eastern and northern sides.

I now understand that this fact has been for some time known to Dr. Geikie, and that the officers of the Survey under him have come across it with equal surprise, in certain parts of Ross-shire. But, so far as I know, it has not been published, and is not generally known.

In one specimen which I obtained on Scalpa there are obscure indications of Annelid borings, together with calcareous cavities, which are very suggestive of an organic origin.

If these rocks really belong to the Cambrian series, as this complete conformability would imply, and if they have been wholly removed in all but a few spots, before the Torridon sandstones were laid down, the fact gives one a good deal to think of both as regards the intervals of time which they represent, and as regards the agencies of change which must have been at work.

To what horizon do these blue rocks belong? The Sutherland fossils from Durness are thought to be among the very oldest Silurian forms. Below these come the great white quartzites of the same county. Below them, again, unconformably, come the Torridon sandstones, and lowest of all come these subsequent blue beds—not at all metamorphosed—less crystalline than many of the secondary rocks. Yet they must be amongst the very oldest sedimentary rocks known to us.

I may add that I found by actual experiment that in a deposit now forming here, of the same blue colour, Annelid burrows develop precisely the same ferruginous stains which I find in the Scalpa specimen before referred to. ARGYLL.

Inveraray, Argyllshire.

Mr. Galton on Natural Inheritance.

MR. GALTON'S recent ingenious book on natural inheritance suggests some remarks on the value of his method and results. In the first place, it is plain that the method of probable error, which he uses, is only applicable with any certainty to cases where a multiplicity of unknown or unanalyzed causes ("accidents," pp. 19, 55) determines some mathematically measurable quality. Eye colour, artistic faculty, and temper, to which Mr. Galton applies his method, are not mathematically measurable qualities, and his results, self-consistent though they are, are scientifically untrustworthy because of variation in the standard of popular judgment in such matters. Stature, however, comes properly within the range of his method, and Mr. Galton has made the most of this point.

The method employed by Mr. Galton may be styled a mathematical interpretation of the law of uniformity of nature as apparent in the tendency of progression and regression to an average for all new examples of measurable qualities. (By the way, it is curious that Mr. Galton does not employ the term progression, instead of making regression cover all movements both upward and downward to an average. Rise to an average is certainly progress.) The comparatively easy method of average in dealing with such problems as heredity in the lump is hardly, what Mr. Galton claims it to be, the pioneer method in the "science of man" (p. 62). Indeed, the method of chance is infertile in both biology and sociology so far as it mistakes statements of average tendency as in any wise comparable in value to the particular predictions given by inductive inquiry. The continued use of such terms as accident and chance to cover a multitude of undetermined particular causes may be directly hurtful so far as this tends to slur over the patient investigation of special cases. The greatest so-called accidental variations, or "sports," have, of course, their reason in a peculiar conjuncture of influences, and the exact determination of these, specially with reference to stable stocks, would be of the greatest scientific and practical value. The method of chance can never be an aid to progress, for it always fails in particular predictions, and reduces our outlook to the level plain of averages.

In a book on natural inheritance we should expect some thorough treatment of the relation of heredity to other factors, and a clear exposition of how it can be isolated from them in its effect, especially upon stature. But the statistics employed are avowedly statistics of stature and not of heredity: how, then, are the results made to stand not merely for stature but also for heredity? Mr. Galton concludes that his results for stature are really laws of heredity because of the peculiar relations of the ratios obtained (p. 132), and also because the results are confirmed by general deductions from the laws of chance (p. 102). But as to this first point we must regard it as assumed rather than proved that kinship is to be measured by the comparison of ratios of deviations amongst kin. If we knew from other investigations or *a priori* that the influence of heredity on regression is in the numerical order given, then Mr. Galton's results would be merely confirmatory evidence. The laws of heredity must be based on the facts of heredity, or it must be clearly shown by the method of elimination that given results can only be ascribed to heredity. Does Mr. Galton accomplish this? He slurs over other influences than heredity (*e.g.* education, p. 156), or he hastily concludes them to be in harmony with heredity (*e.g.* natural selection, p. 119). He also does not satisfy us on the equal influences of parents in heredity (p. 98), which is a fundamental assumption for his process. That the average regression of the son to the general average of stature is by one-third parental deviation (p. 104) does not, on the face of it, prove anything with regard to transmission of stature. I cannot see that Mr. Galton has clearly shown this ratio to be more than a law of stature as determined by all influences and not by heredity alone. To make the ratios obtained a "measure of family likeness" (p. 132) is certainly unproved till it is shown that heredity alone enters into the data upon which the ratios are founded. It is plain that in any case, whether the cause be heredity alone or heredity plus many other influences, certain definite ratios will be obtained for father, son, brother, &c.

As to the way in which an abstract calculation of the laws of chance confirms Mr. Galton's statistics, it is enough to observe that no evidence is adduced why the results attained should not stand for the multiple "accidents" of environment, nourishment, occupation, heredity, &c., rather than to "accidents" of heredity alone. Mr. Galton fails to prove that his ratios are not the mathematical expression for the operation of the law of frequency of error as applied to the chance operation of heredity plus other agencies, rather than the formula for heredity simple and unadulterated.

But stature is undoubtedly modified by many prenatal conditions which do not come under the head of heredity, and it is certainly modified by climate, nourishment, and occupation. It is quite likely that human dwarfs might be raised upon the same principles as the Japanese dwarf trees. Mr. Galton makes no deduction from his statistics for other influences than heredity, and his results stand as the expression of the law of frequency of error applied to qualities which are the effect of many complex causes beside heredity. HIRAM M. STANLEY.

Lake Forest University, October 5.

Head Measures at Cambridge.

I AM pleased to be able to say, with reference to criticisms by your correspondents on the trustworthiness of the head measures at Cambridge, and on the deductions made by myself from the results obtained by Dr. Venn after he had discussed the first batch of them, that he is now about to discuss a second batch. The observations that have since accumulated are about equal in number to those already dealt with, and the new results will afford an efficient check upon the value of those already published. I hope also that Dr. Venn may find adequate material to determine the "probable error" of a single head measure, by means of the differences (discussed under obvious restrictions) between the recorded measures of the same persons at different times. We shall then be better able than we are now to estimate the degree of reliance to be placed on the mean value of any given number of head measures. FRANCIS GALTON.

Trimorphism in *Scabiosa succisa*.

THIS species is usually described as gynodiœcious. Hooker ("Student's Flora") thus refers to it. Darwin ("Forms of Flowers") says, "I have observed the existence of two forms in our endemic *S. succisa*"; further, "From what Lecoq says ('Géographie Botanique') *S. succisa* appears to occur under two forms in France"; and again, "According to Lecoq, the female flower-heads of *S. succisa* are smaller than those of what he calls the male plants, but which are probably hermaphrodites." Hermann Müller ("Fertilization of Flowers") also speaks of *S. succisa* as existing under two forms in Germany.

I have recently discovered that the species really exists, in this country at least, under three very distinct forms, viz. (1) the original hermaphrodite; (2) the small female form described by Lecoq; and (3) a second female form, larger even than the hermaphrodite, and differing from the first in a very remarkable manner. I will describe the three forms in detail.

No. 1 (hermaphrodite). Average measurements of 100 capitula: diameter at the base $\frac{13}{16}$ inch, height $\frac{17}{32}$ inch. Average number of florets per capitulum 86 (highest 111, lowest 53). Corolla lavender. Filaments incurved in bud, afterwards erect, and twice as long as the corolla-tube. Anthers pink. Style about $\frac{7}{16}$ inch long, thin, remarkably erect, purple, glabrous. Plane of stigma at right angles to the style. Development of style does not take place till anthers have fallen, when stigma becomes viscid.

No. 2 (straight-styled female). Average measurements of 50 capitula: diameter $\frac{5}{8}$ inch, height $\frac{3}{8}$ inch. Average number of florets 61 (highest 79, lowest 52). Florets very small. Corolla with a deep lilac tinge. Stamens abortive, filaments very short, within the tube. Rudimentary anthers yellow. Style about $\frac{3}{8}$ inch long, otherwise precisely as in No. 1, but development begins as soon as the floret opens.

No. 3 (bent-style female). Average measurements of 150 capitula: diameter $\frac{7}{8}$ inch, height $\frac{9}{16}$ inch. Average number of florets 58 (highest 79, lowest 22). Florets very large, and more loosely packed on the receptacle. Corolla blue, with a lavender tinge. Stamens as in No. 2. Style about $\frac{9}{16}$ inch long, very stout, much swollen at the base (? honey-gland), usually white, stigma green. Plane of the stigma much inclined. Styles much bent and twisted. The whole surface of the corolla clothed with long stellate hairs. These are thickest on the face of the limb, which in the other forms is quite glabrous. The style is also thickly covered with similar hairs, which are much crowded immediately below the stigma. To these hairs an immense number of pollen-grains may be found adhering. The hairs are not fully developed until the stigma is mature.

Forms in some respects intermediate between Nos. 1 and 2, and between Nos. 1 and 3, are occasionally found, and this