Todhunter; but to make it effective our teachers must be possessed of ordinary common-sense. So long as this is absent, all the elaborate and scientifically improved editions of Euclid's "Elements" in the world will not produce the much-to-be-desired change. Let the teacher go through any edition of the first book of Euclid's "Elements" in a common-sense manner with his pupils, and he will find that, instead of the apathy and general disgust exhibited by them when undergoing the ordinary process of Euclidian cram, there will be a general air of brightness, interest, and intelligent appreciation. H.

The Yorkshire College, Leeds, November 25.

A Brilliant Meteor.

WHILE at my observatory to-night, at 9.37 p.m., I saw the largest and brightest meteor I have seen since November 1880. It became visible near ν Eridani, and disappeared near α Leporis. The colour was a bright greenish blue, and the brightness was twice or three times Venus at greatest brilliancy. It cast a distinct shadow. J. COCKBURN.

St. Boswells, N.B., November 23.

STAR DISTANCES.[1]

THE festal offering contributed by Prof. Oudemans to the Pulkowa celebration is an especially appropriate one. The incidents of the long parallax-campaign can scarcely be recapitulated without recalling, in connection with the name of Friedrich Struve, the *quorum pars magna fui* of Æneas. He it was who, in Sir John Herschel's opinion (Memoirs R. Astronomical Society, vol. xii. p. 442), made the first real impression upon the problem by showing that not one of twenty-seven circumpolar stars discussed in 1819–21 could possibly have an annual parallax amounting to half a second of arc. Thenceforward, astronomers knew what they had to expect. Sanguine hopes of meeting comfortably large, and properly periodical residuals among ordinary observations, were checked, if not extinguished. The changes of stellar position reproducing, according to the laws of perspective, the movement of the earth in its orbit, were perceived to be on a scale so minute that their satisfactory disclosure lay, for the moment, beyond the range of what was feasible. Success in the enterprise, it was evident, was conditional upon the employment of more perfect instruments than had heretofore been available with a precision and vigilance of which the very idea was absent from all but a few prescient minds. Sir William Herschel seemed to have anticipated the conjuncture when he declared in 1782 the case to be "by no means desperate," although stellar parallax should fall short of a single second (*Phil. Trans.*, vol. lxxii. p. 83). The memorable "triple event," by which, almost simultaneously, at the Cape, at Königsberg, and at Pulkowa, his confidence was justified, is familiar to all readers of astronomical history. Its significance may be estimated from Bessel's admission that, until the yearly oscillations of 61 Cygni emerged from his measures in 1838, he was completely in the dark as to whether stellar parallax was to be reckoned by tenths or by thousandths of a second (*Astr. Nach.*, No. 385).

The value to students of Prof. Oudemans' synoptical view of what has since then been achieved in this direction can hardly be overstated. Not only does he record every individual result worth considering, but the tabulated particulars enable a fair judgment to be formed as to the value of each. There are, indeed, one or two cases in which a note of warning might with advantage have been added. Thus, Dr. Brünnow's small parallax for 85 Pegasi, to say the least, requires confirmation. A perfect *equability* in the mode of observing is essential in such delicate operations; but the Dunsink astronomer was himself conscious of, and noted with his usual care, a slight change, as the series flowed on, in his habit of "bisecting" the large star (*Dunsink Observations*, vol. ii. p. 38). The distance of this interesting binary system can hence scarcely be regarded as even approximately known.

Still less reliable, though for different reasons, are Johnson's measures of Castor, and Captain Jacob's of α Herculis. The parallax assigned to the latter star of 0″·062 relative to its fifth magnitude companion cannot be other than illusory, since the pair, as evidenced by a small, but well-ascertained common proper motion, are physically connected, and must therefore be at virtually the same distance from the earth.

Forty-nine stars, all save one measured within the last sixty years, are included in Prof Oudemans' list. The exception deserves particular mention. Samuel Molyneux erected at his house in Kew Green in 1725, a zenith sector by Graham, with which he began, in combination with Bradley, a set of observations for parallax on γ Draconis. The same star had, in the previous century, been similarly experimented upon by Robert Hooke with something of a dubious success. The well-known eventual issue of Molyneux's observations was Bradley's discovery of the aberration of light; but they included besides an element of true parallactic change, brought out by Dr. Auwers's discussion in 1869,[1] after it had lain concealed among them for 142 years. The eye and hand must indeed have been faithful thus to record an ebb and flow of change profoundly submerged, at that comparatively remote epoch, in the reigning confusion betwen the real and the apparent places of the heavenly bodies.

A light-journey of sixty-five years (parallax = 0″·05) may be considered the present limit of really measurable stellar distance. Forty of the forty-nine objects so far investigated lie—most of them certainly, a few only probably—within it. Forty stars can thus be located with some definiteness in space—forty among, say, forty millions! The disproportion between our knowledge on the point and our ignorance is so exorbitant that general conclusions seem discredited beforehand, and negative ones at any rate can have no weight whatever. Nevertheless, one remark at least is fully warranted by the evidence.

It is this, that the largest stars are not always those nearest to the earth. For to the narrow category of stars at ascertained distances belong no less than seven invisible to the naked eye, one of them in closer vicinity to us than Sirius, all than Capella, Vega, Arcturus, or Canopus. A cursory view might almost suggest—irrespective of geometrical possibilities—that stellar brightness had nothing whatever to do with remoteness. The legitimate and certain conclusion to be derived from the facts, however, is that the disparities of stellar light-power are enormous. A farthing rushlight is not more insignificant compared with the electric arc than a faint compared with a potent sun. Sirius emits 6400 times as much light as a ninth magnitude star north of Charles's Wain (Argelander-Oeltzen 11,677); our own sun falls nearly as far short of the radiative strength of Arcturus. Inequalities of the same order between the members of revolving systems emphasize this result. Sirius shines like four thousand of its own companions; and the movements of other stars are perhaps swayed by almost totally obscure bodies.

The inference that the apparent lustre of individual stars tells us nothing as regards their distance was already

[1] "Uebersicht der in den letzten 60 Jahren ausgeführten Bestimmungen von Fixstern parallaxen." Von J. A. C. Oudemans. Eine Festgabe zum 50jährigen Jubiläum der Sternwarte zu Pulkowa. *Astronomische Nachrichten*, Nos. 2915–16.

[1] *Monatsberichte*, Berlin, 1869. p. 630. The result places γ Draconis at a distance of $35\frac{1}{2}$ light-years, but with a very large "probable error" (parallax = 0″·092 ± 0″·070).

drawn by Dr. Huggins in 1866 (*Phil. Trans.*, vol. clvi. p. 393); it has been amply confirmed since, and cannot be too forcibly insisted upon. We are unable to place either an upper or a lower limit to stellar dimensions or intrinsic emissive intensity. Until Arcturus was proved to be immeasurably remote, few would have been disposed to credit the existence of a sun in space at least six thousand times as effulgent as ours is; but we know no reason why Arcturus itself should not be as vastly exceeded by some giant orb at the outskirts of the Milky Way; while we are equally debarred from asserting that among sixth, seventh, twelfth magnitude stars, there may not be found some minute bodies at half the distance from us of *a* Centauri.

But when we pass from particular to general reasoning, the aspect of the matter changes. No cause has yet been shown why the stars should be exempt from obedience to the "law of large numbers" which provides (as Prof. Edgeworth has ably shown) a clue to other labyrinths of facts. Statistics, it is true, are often misleading, but only when they are wrongly employed. The frequent misuse of a method does not justify its total rejection. And the statistical method is peculiarly liable to misuse. Attempts to get from it more than it will properly give inevitably fail; and what it will properly give are general statements which should only be generally applied. An average result may not be the less instructive because it is by its nature incapable of furnishing specific data.

The stars then *must*, on the whole, decrease in brightness as their distances increase, and they must do so according to an underlying fixed law which will be more and more closely conformed to the larger the number of instances included in the generalization. Each descent of one stellar magnitude represents a falling off in light in the proportion of $2\frac{1}{2}$ to 1; it represents, accordingly, an augmentation of distance in the proportion of the square root of $2\frac{1}{2}$, or 1·59 to 1. Theoretically, that is to say, stars of any given magnitude are 1·59 times more remote than those one magnitude superior, $2\frac{1}{2}$ times (1·59 × 1·59), where the gap is of two magnitudes, and so on. This would be strictly and specifically true if all the stars were equal; but since they are enormously unequal, the rule may be grossly misleading in particular instances, and can only, by taking wide averages, be brought to approximate closely to actual fact.

The determination of individual parallaxes has always, with astronomical thinkers, been subordinate to the higher aim of obtaining a unit of measurement for sidereal space. Hence continual attempts to fix the "average parallaxes" of classes of stars, which, however, remained futile so long as precarious assumptions supplied the place of direct information. Nor could this be obtained until the exigencies of the research had evoked improved means of practically meeting them. The earlier observers chose the subjects of their experiments entirely with a view to their successful issue. Stars likely, owing to their brilliancy, their swift motion, or both combined, to be nearer the earth than most others, were picked out for measurement, with results, each by itself of high interest, but worthless for generalizing purposes. It is only a few years since increased skill in the handling of methods authorized an extension of the range of their application. The first systematic plan for investigating "mean parallax" was proposed by Dr. Gill in 1883, and is now in course of combined execution at Yale College and the Cape. The completion last year of a section of the work enabled Dr. Elkin to deduce an average distance of thirty-eight light-years for the ten first magnitude stars of the northern hemisphere; but it would of course be folly to regard this avowedly "provisional and partial" result as a satisfactory basis for definitive conclusions about the distances of more remote classes of stars. At the most, it makes a useful temporary starting-point for some trial-trips of thought through space. Before long, however, through the exertions of Dr. Gill and Prof. Pritchard, direct measures, not only of all the first, but of most of the second magnitude stars all over the sky, will have been executed; and the proportion between distance and brightness thus established may with some confidence be used as a fathom-line for sounding otherwise inaccessible sidereal abysses.

A. M. CLERKE.

DR. H. BURMEISTER ON THE FOSSIL HORSES AND OTHER MAMMALS OF ARGENTINA.[1]

THIS handsome volume is a continuation of the author's monograph on the fossil horses of the Pampean beds of Argentina, of which the first part was published at Buenos Ayres in 1875, and is stated to have been specially brought out for the Paris Exhibition. The author has, however, not done himself justice as regards the title of this portion of the work, since, in addition to the description of remains of the horses of the Pampean, he also describes and illustrates the osteology of *Megatherium*, *Mastodon*, and *Macrauchenia*, so that a better title for this volume would have been "The Fossil Horses and other Mammals of the Pampean Deposits."

Like the former part, the text of this volume is printed in parallel columns of Spanish and German; and the execution of the plates leaves nothing to be desired, so far as a clear delineation of the essential features of the specimens portrayed is concerned. All the specimens forming the subject of this monograph, are, as we learn from the introduction, preserved in the National Museum at Buenos Ayres, of which the learned author is the Director; and, so far as we may judge from the description and figures, that collection of fossil mammals must be unrivalled in the excellence and completeness of its specimens.

The first section of the work, or that to which the title alone properly applies, is devoted to the horses; and the author commences his description by observing that the *Equidæ* differ from all other Ungulates in that the premolars are larger than the true molars. For the more generalized species of the Pampean deposits, like *Equus principalis* of Lund, Dr. Burmeister adopts the Owenian genus *Hippidium* (*Hippidion*), remarking that these forms are distinguished from the modern horses by the shorter and more curved crowns of their cheek-teeth, which are of a more simple general structure, and also by a difference in the form of the narial aperture, as well as by their shorter limbs and stouter limb-bones. In the

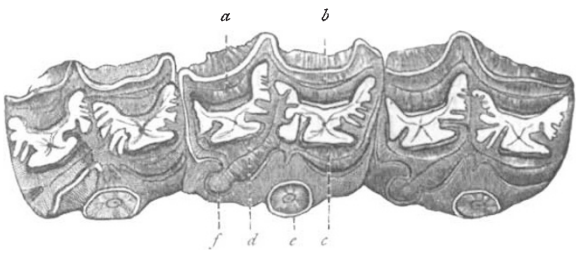

FIG. 1.—Three right upper cheek-teeth of *Hipparion*, *a*, posterior, and *b*, anterior outer crescent; *c*, anterior, and *d*, posterior inner crescent; *e*, anterior, and *f*, posterior pillar.

structure of their upper cheek-teeth the horses of this peculiar South American group make, indeed, a decided approach to the more generalized representatives of the family, such as *Hipparion*. In the latter the anterior pillar of these teeth (Fig. 1, *e*) forms, as is well known, a

[1] "Los Caballos Fósiles de la Pampa Argentina," Suplemento. ("Die fossilen Pferde der Pampasformation," Nachtrags Bericht.) By Dr. Hermann Burmeister. Folio, pp. 65, pls. 4. (Buenos Ayres, 1889.)