having a distinct dorsal stripe on the otherwise dun back, and a well-developed forelock, while the muzzle, with the exception of the nose[1] (which is whitish), is said to be black, and the tail, which appears to be haired to the root, is rather short and bushy in winter. Moreover, the colour of the tail and mane is said to be reddish-brown. Nothing is stated with regard to the front of the legs being black.

So far as can be determined from this description, the tarpan appears identical with *Equus caballus* (of which it is probably the ancestral form), which is certainly not the case with *E. przewalskii*.

But another important point arises in connection with the animal under consideration. Naturalists commonly divide the existing species of Equus into two groups, the one containing only the horse, and the other the asses and zebras. Przewalski's horse will, however, clearly find a place in the former group, and as this animal approximates in some respects to the kiang, which differs from the African wild asses by its shorter ears, larger hoofs (especially the front pair) and absence of a shoulder-stripe and bars on the legs, I am inclined to think that the horse, Przewalski's horse, and the kiang (Asiatic wild ass) form one natural group, and the African wild ass, quagga and zebras a second. This arrangement will harmonise with distribution much better than the old one

Taking the tarpan as the wild representative of the horse, it will be noticed that all three members of the first group agree in the general absence of the sh oulder-stripe and of dark markings on the legs. And the question then arises, how is it that certain domesticated horses (especially dun-coloured ponies in the Punjab) show both these markings? Can it be owing to a cross with the African ass, or is it due to reversion to the common ancestor of the equine genus? R. L.

TYCHO BRAHE'S OBSERVATORY.

IT was mentioned in a recent article on the tercentenary of Tycho Brahe's death (p. 6) that an account of excavations made in the island of Hveen has been published by Prof. Charlier, of Lund.[2] As Tycho's observatory has thus again attracted attention, it may not be out of place to give a short description of it as it was three hundred years ago, and of the very few remains of it now brought to light.

Tycho's magnificent buildings were destroyed less than twenty-two years after his death. In 1623 a mason was paid for 60,000 bricks "which he had pulled down and renovated from the old castle," and they were used to build a new dwelling-house at a little distance, which in its turn has disappeared within the last hundred years. Apparently the peasants of the island helped themselves to bricks and stones as much as they liked, as part of the foundation-stone (laid by Tycho's friend the French envoy, Charles de Danzay) was recently discovered in the wall of an outhouse of a farm on the east coast of the island, still showing part of the Latin inscription and the date 1576 August 8. When Picard was sent over by the Paris Academy, in 1671, to determine the geographical position of Uraniborg, only the foundations of the house and the greater part of the ramparts surrounding it were still intact, while on the site of the observatory only a slight hollow in the ground was noticeable. Picard did not trouble himself about making excavations, and apparently everything was left undisturbed until 1823, when the clergyman of the island, Ekdahl, made careful excavations. At Uraniborg he found the deep well which was under Tycho's kitchen and still supplies the neighbourhood with excellent water, while parts of the foundation-walls and some slight remains of the laboratory (in the basement of the house) were also unearthed. These must have been covered over again, as nothing was visible on this spot until the present year, when the same trifling ruins of Tycho's beautiful residence were again laid bare; but as nothing of any scientific interest was found, we may at once pass to the underground observatory, of which much more distinct traces still remain.

Uraniborg, the stately residence of Tycho Brahe, was finished in 1580 and contained four observing rooms, two at the north and two at the south end of the building. But already a year or two later a large meridian quadrant was erected in one of the sitting-rooms, and very soon, as the work increased, it was found that even with this addition to the equipment more instruments were wanted. In 1584 an observatory was therefore built on a low hill about a hundred feet south of the south corner of the enclosure of Uraniborg and slightly to the east. This observatory, of which we here give a view from the west and a plan,[1] was called Stellæburgum (Danish, Stjerneborg); in it the instruments were placed in three subterranean rooms (C, G and F on the plan), of which only the roofs rose above the ground, so that they were well protected from the wind. The entrance was to the north, and in the centre was a study, lighted by four small windows just above the ground, and which could be heated by a stove in a recess (at P), while off it there was an alcove with a bed where Tycho could rest during cloudy intervals. In 1585 two other rooms for instruments (D and E) were added, but the floors of these were almost on the level of the ground, probably because he had found it inconvenient not to be able to observe stars near the horizon from the three underground rooms. The whole was surrounded by a low wooden paling, forming a square with sides 57 feet long, with semicircular bends at the middle of each side of 20 feet diameter, and stone piers were placed inside the

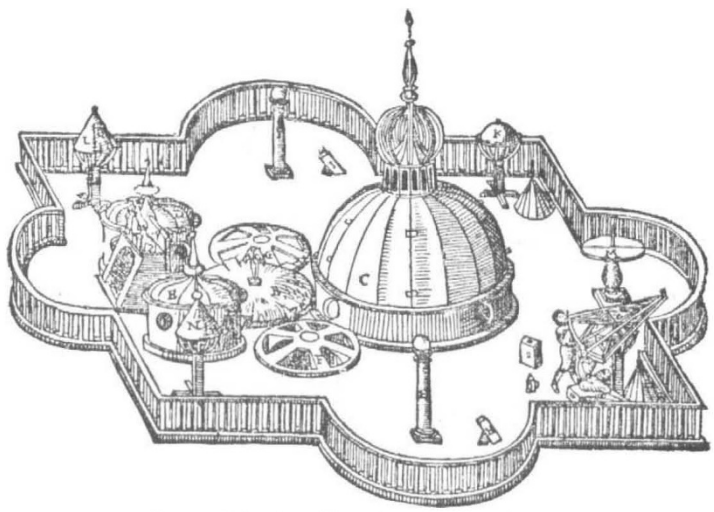

FIG. 1.—Stjerneborg Observatory, seen from the west.

[1] The expression "nose" is a little ambiguous, but the figures do not show a white muzzle like that of *E. przewalskii*.

[2] "Utgräfningarna af Tycho Brahe's observatorier på ön Hven sommaren 1901." Beskrifna af C. V. L. Charlier. 20 pp., 4to, with 3 plates. (Lund, 1901.)

[1] Taken from the writer's book, "Tycho Brahe," by permission of Messrs. A. and C. Black.

enclosure, on which portable instruments could be used when necessary.

In the centre of each crypt was a large instrument, the floor rising gradually by circular stone steps (shown on the plan) up to the walls. The floor of the crypt G was, however, flat; in it was placed a sextant of 5½ feet radius for measuring angular distances in any plane. In the southern crypt (C) there was a large equatorial instrument, consisting of a declination circle of 9½ feet diameter, revolving round a diameter parallel to the earth's axis, and having a semicircle of 12 feet diameter, supported on stone piers and representing the northern half of the equator. In the crypt F stood a quadrant of 7 feet radius, enclosed in a square and with an azimuth circle on the wall, in D another quadrant somewhat smaller and in E a zodiacal armilla like those used by the ancients. Of these instruments those in C and F were the most important, and an immense deal of valuable work was done with them.

Of this observatory and of the instruments in it very full and well-illustrated descriptions were published by

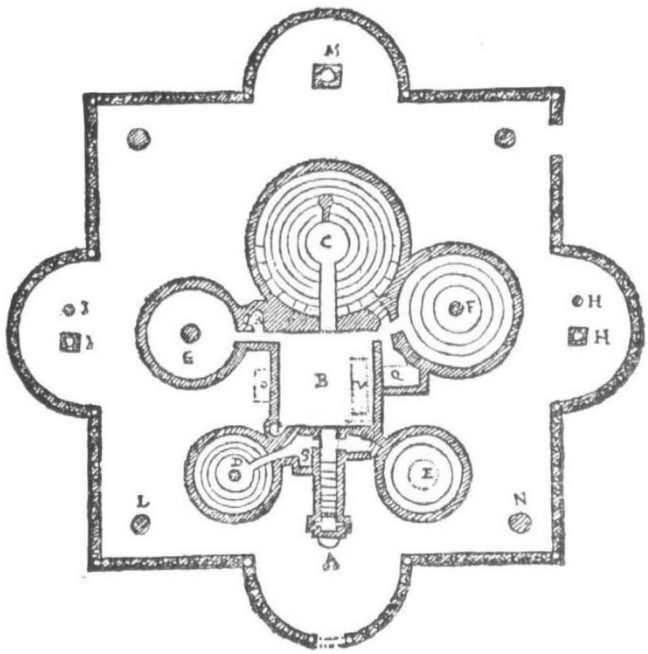

FIG. 2.—Plan of Stjerneborg:—A, entrance; B, study; C, crypt with largest armillæ; D, crypt with quadrant: E, crypt with zodiacal armillæ; F, crypt with largest quadrant; G, crypt with sextant; H, I, stone piers for portable armillæ; K, L, N, T stands for sextants; M, stone table; O, Tycho's bed; P, stove; V, table: Q, bedroom for assistants; S, unfinished underground passage towards Uraniborg.

Tycho. When he left Denmark he took all his instruments with him except the four largest, two of which were those in the crypts C and F, and the large equatorial was actually used by an assistant to observe the partial eclipse of the sun of February 25 (March 7), 1598.[1] They were, however, subsequently dismounted and sent to Bohemia, where every single instrument from Hveen was destroyed during the thirty years' war, except Tycho's large star-globe, which found its way back to Denmark only to perish in a great fire in 1728.

When Ekdahl, as already mentioned, examined the site of Stjerneborg in 1823–24, he found without difficulty the floors of the central study and of all the crypts more or less well preserved, one of them (F) being almost perfect, with the four circular steps and the short stone pillar in the middle on which the quadrant had been fixed. In the course of years everything became again covered with earth and grass except the crypt F, which was always visible, though generally more or less full of water. It furnished a valuable clue to the unit of linear measure employed by Tycho, as d'Arrest, in 1868, found the diameter of the crypt to be 11⅓ Paris feet, which must be equal to the diameter of the azimuth circle of the quadrant which Tycho states to have been nine cubits. This gives one cubit = 16·1 English inches = 40·9 centimetres. Tycho, however, also makes use of feet, and d'Arrest found to his surprise, on measuring the length of the ramparts round Uraniborg, that the whole place was much smaller than the figures given by Tycho had led him to expect, the enclosure being only 233 French feet square instead of 300. The discrepancy was, however, easily cleared up, as Picard had carefully measured the great star globe in 1671, which gave one Tychonic foot = 0·815 English = 24·9 centimetres. These figures are of importance, as it is of interest to know the exact dimensions of the instruments, by means of which so great a revolution in practical astronomy was carried out. For instance, the radius of the great quadrant (in F) was five cubits long; one minute of arc was, therefore, 0·6 millimetre in length, and as Tycho says that he could by his transversal divisions distinguish 10″, this means that he could read off the arc to a tenth of a millimetre. In reality the accuracy attained was hardly as great, the probable error of one measure of altitude being certainly more than half a minute. But even this was a wonderful advance on what had been possible before Tycho's time, when errors of three or four minutes were unavoidable.

During the past year the site of the observatory has again been thoroughly excavated under the supervision of the Swedish inspector of antiquities and Prof. Charlier, of Lund. From the account published by the latter it appears that the tiled floor of the central study is almost perfectly preserved; it is 4 metres long (from north to south) by 3⅓ metres broad. The floor of the alcove where Tycho's bed stood is also visible, the dimensions being only 185 by 125 cm. As it seems to have been completely underground, this tiny and grave-like bedroom can hardly have been a healthy place of rest, and it is to be hoped that the energetic observer did not use it very often. The floor of the study was found to be two metres below the ground. As Prof. Charlier's account is in Swedish, it may not be useless to give here a summary of the results of his examination of the five crypts. Of D, G and C the floors are left, all on the same level as the floor of B, and in D also the short pillar to which the lower end of the vertical axis of the quadrant was attached. The polished stone floor of E was 125 cm. above that of the study B and the steps leading up to it from the little vestibule north of the study are still intact. But the crypt F is almost in perfect preservation, with its four steps, the floor being 122 cm. below that of the study (or 10 feet below the ground), the inner diameter of the lowest step being 88 cm. and the outer diameter of the top step 345 cm. The top step was exactly on a level with the floor of the study. As the diameter of the top step was of importance for fixing the length of Tycho's cubit, it was measured again by a second observer, who found 354 cm. The mean of the two measures gives 1 cubit = 38·8 cm., agreeing sufficiently well with the 40·9 found by d'Arrest. Prof. Charlier found the value of a Tychonic foot from measures of the length of the foundation-wall of Uraniborg equal to 23·8 cm.; but as Tycho only says that the side of the square was "circiter pedes 60," this result can hardly be as accurate as that deduced from Picard's measure of the star-globe, as it seems likely that the latter was exactly 6 Tychonic feet in diameter, which Picard found equal to 55 1/12 French inches.

[1] See *Monthly Notices* R.A.S., vol. liv. p. 439.

The account of the recent excavations of Tycho's observatory thus forms a valuable supplement to the description published by Tycho himself. The idea of seeking shelter from the wind, by erecting his large instruments a couple of feet below the level of the ground, was a good one, and on the small island the force of the wind was doubtless not a negligeable quantity, particularly as the observatory was situated almost at the highest point of the island, about 160 feet above the sea, which is visible in all directions except in the south-east. Picard remarked that except where some hills in Scania rise to an altitude of 11′, he had often seen the stars down to the very horizon, which he considered very surprising, as this was never possible at the Paris Observatory, although the latter was about 120 feet higher than the level of Tycho's observatory. But the example thus set by Tycho was not followed; for more than a hundred years the object seemed generally to be to get as near to the stars as possible by placing observatories on the top of towers and high buildings—and in the midst of crowded cities. The nineteenth century has reverted to Tycho Brahe's ideas by building observatories at some distance from cities and with the instruments at very moderate heights above the ground. Another idea of Tycho's, which was not adopted for several centuries, was to have a large staff of assistants, among whom the work of the observatory was divided. He had cherished the hope for many years that the institution founded by him would be made a permanent one and not come to an end with his own life. Unfortunately he did not succeed in getting this settled in the lifetime of his benefactor, King Frederic II., and when he finally found that not only was it hopeless to expect a permanent endowment, but that even some of the valuable grants he had enjoyed for years were taken from him, he resolved to try if some other monarch would carry out his favourite idea and found a public observatory on a large scale. But Tycho had been very many years in his grave before this was done anywhere.

J. L. E. DREYER.

TECHNICAL SCHOOLS FOR RURAL DISTRICTS.

ENCOURAGED by the success which has attended the work of her sister, the Countess of Warwick, at Bigods, near Dunmow, in Essex, the Duchess of Sutherland has boldly entered upon a scheme for providing a technical school in a still more remote rural district, viz. near Golspie, on their Dunrobin estate in Sutherlandshire. No provision for secondary and technical education in the Scotch Highlands at present exists, and the proposed school must meet a long-felt want. The draft scheme which has been drawn up by the Duchess with the cooperation of Prof. Meldola provides for the education of fifty pupils in the principles of those sciences which bear in any way upon the local industries, including agriculture. The pupils will be taken from the elementary schools and admitted only when fully qualified to take advantage of the secondary training offered by the Sutherland school. In view of the excellent character of the elementary teaching in the Scotch schools, there should be no difficulty in finding a constant supply of promising pupils, the more especially as the new school is intended for board and residence and caters for the four counties of Sutherland, Ross, Cromarty and Caithness. Like Bigods, the Sutherland technical school is to be mixed and the curriculum adapted to the requirements of boys and girls. As stated in the scheme :—

"It is impossible that education in the Highlands should continue on the present lines. There is practically no technical training whatever. The old form of 'classical' education is still persisted in, and often a whole school suffers for the sake of three or four clever pupils who win the bursaries which send them to the University, from whence they issue as clerks, doctors or ministers as the case may be. The others are left to drift into idleness or to go away south to add to the population of our already over-crowded cities. The overcrowding of the fisher class is undisputed, and the dearth of skilled masons, carpenters and artisans, or competent hand-workers in the north, apart from the homespun tweed industry, is remarkable. There have been many peripatetic technical classes carried on under the County Councils and School Boards in the north, but this is the first technical school of the kind that has been started in the Highlands. It should be the pioneer of much educational reform, and it is started with a great belief in its ultimate possibilities."

The scheme has been considered by many educationists and has been approved of by Lord Balfour of Burleigh, Mr. Struthers, of the Scotch Board of Education, Sir Swire Smith, Mr. James Baker, Prof. Magnus Maclean and others. Practical appreciation of her Grace's efforts in the cause of education has also been shown by the substantial support which the scheme has already received. The Duke of Sutherland has given the site for the building and land for the agricultural work close to Golspie, besides 5000*l.* towards the building and equipment fund. Mr. Andrew Carnegie contributes 5000*l.* to the same fund and Mrs. Carnegie two bursaries of 30*l.* each annually. The Duke and Duchess of Sutherland, the Dukes of Westminster and Portland, and Mr. James Coates, of Paisley, also contribute annual bursaries. The work thus commences under very good auspices and is worthy of the most cordial support by all who are interested in the welfare of Scotland. At the present time, when "official" educators are, as was said recently, whistling for the wind of popular opinion, the country may well be proud of the splendid examples set by the Countess of Warwick in Essex and by her sister in the Highlands of Scotland. As pioneers in the introduction of scientific education into rural districts the names of these ladies will be written large in the annals of our educational development.

A PERIODICAL FOR STATISTICAL BIOLOGISTS.[1]

THE receipt of the first part of the new periodical, *Biometrika*, calls for more than mere formal acknowledgment. The methods of investigating biological problems statistically may be looked upon as having their origin in this country, and the names of the editorial staff are those of the pioneers in this modern departure—Francis Galton, and Profs. W. F. R. Weldon and Karl Pearson, associated with Prof. C. B. Davenport, of the University of Chicago. The part received is prefaced by an editorial article setting forth the scope and defining the spirit of the publication and an article on biometry from the pen of Mr. Galton. An admirable figure of the Darwin statue in the University Museum at Oxford, reproduced from a photograph by Mrs. E. B. Poulton, forms an appropriate frontispiece, the motto "*Ignoramus, in hoc signo laboremus*," being printed below the illustration. The papers contributed to this first part are seven in number, including those already mentioned. Prof. Dr. F. Ludwig writes (in German) on problems and materials for variation statistics; Mr. A. O. Powys con-

[1] *Biometrika*. A Journal for the Statistical Study of Biological Problems. (Cambridge: University Press. New York: The Macmillan Company.) Price 10*s*.