From the CLUB.—Proceedings of the Berwickshire Naturalists' Club. Vol. X, No. 3.
From the SOCIETY.—Proceedings and Transactions of the Royal Society of Canada for the year 1884. Vol. II.
—— Proceedings of the Royal Geographical Society, 1886. No. 2.
—— Journal of the Royal Geological Society of Ireland. Vol. VI, Part 3. New Series.
—— Transactions of the Asiatic Society of Japan. Vol. XIII, Part 2.
—— Journal of the Society of Arts. Nos. 1730–1733.
—— Bulletin de la Société Impériale des Naturalistes de Moscou, 1884. No. 4.
—— VII. Jahresbericht der Geographischen Gesellschaft von Bern, 1884-1885.
From the EDITOR.—Nature. Nos. 846-849.
—— Science. Nos. 152–155.
—— Revue d'Anthropologie, 1886. No. 1.
—— Revue d'Ethnographie, 1885. No. 5.
—— L'Homme. Nos. 23, 24.
—— Matériaux pour l'Histoire de l'Homme, 1886. Jan.

The election of the following new Members was announced:—

Professor OTIS T. MASON, of the Smithsonian Institution, Washington; Professor J. RANKE, of Munich; Dr. L. MANOUVRIER, of Paris; and Professor J. KOLLMANN, of Basel, as Honorary Members; and the Rev. W. BIRKS, of Wanstead Villa, Villier's Road, Southsea; J. G. BLUMER, Esq., of Satis House, Darlington; F. H. COLLINS, Esq., F.L.S., of Churchfield, Edgbaston, Birmingham; I. SPIELMAN, Esq., of 3, Westbourne Crescent; and T. L. WALL, Esq., of Leyland, Preston, as Ordinary Members.

Mr. HORACE DARWIN exhibited several Anthropometric Instruments made by the Cambridge Scientific Instrument Company.

M. COLLIN, of Paris, exhibited a Traveller's Box of Anthropometric Instruments.

Professor A. MACALISTER, F.R.S., exhibited a skull from an ancient burying ground in Kamtchatka.

The following Paper was read by the President:—

On RECENT DESIGNS *for* ANTHROPOMETRIC INSTRUMENTS.

By FRANCIS GALTON, F.R.S., President.

IT is rather more than a year since I submitted, for criticism and discussion, the instruments that I employed in my temporary

anthropometric laboratory at the International Health Exhibition, South Kensington, in 1884. Since then, further experience of their use, and the results of your discussion of them, have led to modifications and new designs. These I again desire to submit to your helpful criticism. They are made by the Scientific Instrument Company in Cambridge, whose two able directors, Mr. Horace Darwin and Mr. Dew Smith, have kindly acted as members of the small committee who superintended the measurements made with my instruments during the past year at Cambridge. They are therefore well qualified to design and carry out improvements in them. The other instruments on the table are those recommended by M. Topinard, Professor of Anthropology in Paris, for the use of travellers, and described by him in his Anthropométrie Générale. They are very ingeniously made and packed into a portable box, but with the exception of a dynamometer to test the strength of squeeze, they refer wholly to linear measurements of the body and its parts.

I have received numerous letters concerning the establishment of anthropometric laboratories at various places, and on the addition to laboratories that already exist, of apparatus to measure various faculties. A frequent desire is also expressed for instruments and instructions to measure the head. It is to these points—measurements of the faculties and measurements of the head—that I principally desire to call your attention now.

First of all, let us consider the *cui bono* of making any measurements at all. The chief object of them, as it seems to me, is to define the individual or the race, and to show in what way, and to what extent, he or it differs from others. So far as the individual is concerned, measurements teach him to know his own powers at any given time. The second important object is to keep watch over the development during the period of growth, and to give timely warning if it does not proceed normally. Just as the examinations in books, with which every student is now only too familiar, test the amount and progress of his intellectual acquirements, so these other examinations test his strength and swiftness, his keenness of sight, hearing, and touch; his colour sense, his power of distinguishing slight differences in musical notes, his quickness of response to stimulus, and not a few other elementary psychical facts.

The sort of letters that I receive may be best shown by examples. One that reached me about six weeks ago came from a Japanese professor in the University of Tokio, who had been educated and taken his degree at Cambridge, stating that his Japanese students had subscribed a sum of £36 for the outfit of an anthropometric laboratory, and he asked me to order such

instruments as I thought most suitable. The list that he enclosed of the desired objects of measurement, contained those of which I have just spoken.

Professor Giuseppe Sergi, of the University of Rome, writes to say that he desires to add to his anthropological cabinet a specimen set of instruments for use in schools. He enclosed a pamphlet in which his views on their utility are set forth, and desired me to select a list for him.

M. Topinard, professor of anthropology in Paris, whose experience of the art of measuring the linear dimensions of the living human body, and those of the skull and other bones, is unsurpassed, writes to me to the following effect upon what I have called the measurement of faculties:

> I have written nothing as yet concerning physiological instructions to travellers, awaiting a convenient moment for doing so. I am disposed to take directly your system, and will ask to have all your apparatus sent to me. We possess no samples of colours for hair and eyes beyond the polychromatic table of Broca, which the Anthropological Institute employs, but I am about to undertake new work of this kind, and intend shortly to have some samples made; but not many of them, probably five for eyes and five for hair. My present difficulty is to select the exact shades and tints; if you have yourself made any such sets, I should be much obliged if you would let me have one.

I have also very lately received letters from two gentlemen who have just joined our institute, one of whom, Mr. Spielman, is already commencing a series of observations on a large scale, and both of whom are establishing anthropometric laboratories.

It is therefore obvious that a decision cannot be delayed as to the best instruments procurable for the above-mentioned purposes, in respect to facility of use, accuracy, portability, and cheapness. There is no finality in any design; I hope we shall always go on improving; but what is requisite now is to find the most satisfactory design that already exists or can at once be suggested, and to recommend its use until it shall be superseded by something distinctly better.

I will first ask your attention to the measurement of the head. Its object is to show, indirectly, how much and up to what age the brain continues to grow in bulk in different individuals, especially with a view of comparing the uneducated classes with those who are educated. It is well known that the size of the caps worn by university students much exceed that of the uneducated population, and it is therefore a matter of much interest to learn both generally and individually at what age the growth of the brain comes to a standstill under different circumstances. Unfortunately the measurement in question is difficult

to make with completeness. Craniologists, who are able freely to manipulate a skull, and have no trouble about varying thickness of skin and density of hair, and who see all the markings of the skull, have been long in coming to a general opinion, even if that is already reached, as to the best way of measuring it. Much less is it to be hoped that any general consensus will be arrived at soon as to the best way of measuring the living head. The maximum breadth of the head is easily taken by calipers or by sliding bars, if they are furnished with blunt teeth like a comb, in order to penetrate the hair and reach the skin. The maximum length of the head is also easily to be taken if we start from the glabella (the point between the eyebrows) or from the smooth spot above it. Probably it would be thought worth while to make both measurements. That from the glabella alone seems objectionable, because the frontal sinus grows rapidly in early adult life, and so far as it does this, a measurement that includes it would give an erroneous idea of the contemporary growth of the brain. The measurement of the height of the head is the great difficulty. It has to be taken at right angles to some very clearly defined plane of reference; and the question is, what plane of reference should be selected? The instrument I have used was made by Mr. H. Darwin and lies upon the table. It takes measurements from the plane that passes through two pairs of symmetrical points, namely, the two earholes and the upper and inner edges of the orbits, the latter affording an excellent catching place to hold a slight projection at the bottom of the instrument, without any risk of hurting the eyeball. The earholes are less satisfactory. It is a question whether a better plane of reference might not be found in that which passes through the upper edges of the orbits as before, and through the occipital tuber (or the inion), and to measure the height of the head by a perpendicular to that plane which crosses the earhole, or the middle of the tragus (the small portion of the external ear which covers the earhole as with a flap).

On these points I hope that the eminent craniologists present will favour me with their opinions and advice.

[The subject was subsequently discussed by Professors Flower, Macalister, and Thane, and by Dr. Garson, who all agreed that a plane of reference passing through the *lower* and outer edges of the orbits and the earholes was a good one, if the instrument was pressed firmly down against the edges of the orbit, by a band under the chin or otherwise. Mr. H. Darwin would alter the existing instrument so as to adapt it for this purpose. It was also agreed that the occipital tuber was not a good point of reference. —F. G.]

Standards of colour for eyes and hair.—Printed tints, like those of Broca and of Chevreuil, fade, and it is very difficult to compare the colour of hair with any flat tint. I have suggested the use of glass in small discs for comparison with eyes, and the same glass spun by a glass-blower for comparison with hair. Mr. H. Darwin is preparing specimens of these.

Dynamometer.—The common dynamometer for squeeze of hand is untrustworthy, because the maximum power of the squeeze much depends on the size of the object, at the moment of maximum strain, being convenient to the grip. In the ordinary instrument a strong man soon brings the handles so nearly together that his maximum strain is exerted very disadvantageously to his muscles. Mr. H. Darwin has devised a new instrument to remedy this, but it is not completed.

Sight.—I lay on the table the pattern of the instrument I used for testing acuteness of sight, but shall not say anything now about it, as I understand that it has been criticised at Cambridge, and I hope that those objections will be re-stated here, and so far as possible remedied.

Last spring the interesting question of the relative acuteness of sight among civilised and uncivilised people was forcibly brought forward by Mr. Brudenell Carter, and it was hoped that some very simple tests, such as travellers might successfully apply to wholly uneducated and suspicious barbarians, could be devised. A small committee of the Institute, including Mr. Brudenell Carter, considered the question on several occasions, but it was not found at that time possible to frame sufficiently simple tests that should cover all the points in which the total efficiency of the sight of a savage might be deemed to depend. For my own part, I am prepared to conform to the adage of "a half-loaf being better than no bread," and to content myself provisionally with an inquiry into the relative facility with which a single black dot near the corner of a square white card could be seen by men of various races, the position of the dot and the size both of the dot and of the card being specified. The test would be to expose the card as it rested on any one of its sides, and to require the observer to indicate in which of its corners the dot lay. Sometimes, as a so-called "puzzle case," the blank back of the card would be exposed. This test could be easily applied, and it would at all events tell us something; though it would not fully solve the question whether the efficiency of sight among savages in detecting distant objects was or was not generally superior to that of the civilized traveller who tested the card himself at the same time and under the same circumstances.

Colour-sense.—Mr. H. Darwin is engaged on a simple instru-

ment for testing the colour-sense. A singularly instructive account of a vast number of varied experiments made by another apparatus has just been published in *Brain*, and will, I understand, appear with very full details in *Mind*, by Dr. Cattell, a young American, who is now assistant in Professor Wandt's laboratory at Leipzig. The apparatus is in principle what photographers would call a drop shutter; its object is to give a very brief but measurable exposure of a colour of one or more letters, or numerals, or of a word. The instrument is applied to many purposes; that which now concerns us is the colour-sense. It appears that every object, whatever may be its colour, seems grey when looked at for a time a little less than one-thousandth of a second. When the exposure is prolonged the sense of colour begins to be excited, but it requires a longer exposure to see some colours than others. Measured in ten-thousandth parts of a second the averages are as follows:— Orange requires an exposure of 8; yellow of 10; blue of 12; red of 13; green of 14; and violet of 23, or nearly three times as much as orange. A very large number of experiments were made on seven persons, and in each case the figures were constant, but the individual differences were large. I find, in reducing Dr. Cattell's figures, that the relative sensitivity for red and violet also differed considerably among these 7 persons, and to the following extent: 1 case in which it was 14; 3 cases of 16; 1 of 17; 1 of 20; and 1 in which it was 23. Thus out of seven persons, one was relatively twice as sensitive to violet, as compared with red, as another. This instrument might, therefore, perhaps serve as a test of colour-sense, but it has physical adaptations as well. In the first place, it shows how many letters, numerals, or lines can be grasped by consciousness during a brief exposure, and this proves to be a very variable gift, certainly in some way connected with the general grasp of the mind, but this has to be experimented on further. In the second place, it seems that this instrument may perhaps afford a much desired measure of general nerve fatigue—it certainly affords one of eye fatigue, as the exposure has to be increased considerably after the eye becomes wearied. It is very probable that Dr. Cattell's instrument, in perhaps its rudest form, without an electro magnet, will be found of much future anthropometric service for general use.

Sound.—I wrote to Dr. Cattell, asking him what good instruments existed, to his knowledge, in Germany or elsewhere for giving a sound of standard loudness. He replies:—

As far as I know, no sound of standard loudness has been agreed upon. When I wished to specify the sound used in certain experiments, I let a ball of a given weight fall from a given

height, the material of the ball and the nature of the surface on which it fell being also given. The loudness of the sound in this case is not in proportion to the height from which it fell, multiplied into the weight of the ball, and into a constant depending on the material, as has been assumed. Vierordt (*Zeitsch. f. Biologie*, 1878) gave the formula $i = p\sqrt{h}$; Overbeck (*Wiedermann's Annalen XIII*) $i = p\,h^{\cdot 641}$. New experiments from our laboratory are about to be published.

Mr. H. Darwin has designed an instrument emitting a faint sound, suitable for testing the acuteness of hearing.

Distinction of Notes.—Dr. Cattell says:—

We have in the laboratory two excellent pieces of apparatus for testing the power of distinguishing notes. The one is an organ arrangement, which gives the notes at intervals of four vibrations from 32 to 1024. This is made by Appunn in Hanau a/M. and each octave costs, I think, about £20. The other apparatus is a set of tuning forks made by König, in Paris. Pairs of tuning forks are taken, one always gives the same note, the other (by means of weights) can be so regulated as to give a note a little lower or higher. Experiments on this subject are being made by three groups of students, and the results will be published (in Wandt's *Studien*) during the year. In one case, memory of notes is being especially investigated.

Mr. H. Darwin will submit a much less costly instrument than either of these, for the purpose of ordinary anthropometry.

I will now call upon him to explain the instruments in order, and will ask you to discuss each in turn.

Discussion.

Mr. BRUDENELL CARTER said he feared his objection to the proposed test for sight was a fundamental one. He regarded it not at all as a test of acuteness of vision, which was the thing desired, but only as a test of the acuteness of perception of slight differences in the intensity of light. The perceptive surface of the retina might be described as a mosaic composed of hexagonal elements, and he would assume, for the purpose of illustration, that the image of the entire card covered six of these elements. In that case, one retinal element would receive the image of one-sixth of the card. If the superficial area of the spot were one-twentieth of that of one-sixth part of the card, one of the six retinal elements would receive an image one-twentieth part less luminous than the images received by the other five elements; and thus, although the spot itself might not become an object of vision, its position on the card would be revealed, supposing that the retina was sufficiently sensitive to small differences of light for a difference of one-twentieth between adjacent parts of the whole image to be perceived. He contended that nothing was an accurate

test of acuteness of vision, unless it called upon the person tested to see the separateness of two or more objects, such as spots, which were separated from each other by intervals equal to their own diameters. The separateness of such objects did not become visible until their retinal images were so large that the image of the interval between them completely covered a single retinal element. Until this condition was fulfilled, two or more dots, although their position might be discoverable as a matter of luminosity, as in the familiar case of double stars, discoverable as single ones by the naked eye, could not be said to be either objects or tests of vision, properly so called. He hoped that the labours of the Committee on the subject were not concluded, and that they would be able to arrive at some simple and practical test composed of two or more dots or other objects.

Exhibition *of* Anthropometric Instruments.

By Horace Darwin, Esq., M.A.

Mr. Horace Darwin apologised for the incomplete state of the apparatus exhibited. He first showed an instrument for testing the keenness in distinguishing small differences in the pitch of a musical note. An organ pipe giving about the middle C was blown by a bellows. Its pitch could be altered by a known amount by changing its length. Constancy of air pressure is of considerable importance, and could easily be obtained with a more perfect bellows.

The next instrument shown was a chronograph made according to the design of the President, Mr. F. Galton, for measuring the quickness with which a person can press a lever after a sound signal is given. A wooden rod is supported at its upper end by a detent, and can be released at will. The rod then falls freely in space passing through a hole in a fixed diaphragm. A weight in the form of a ring, larger than the hole in the diaphragm, rests on a collar near the top of the rod. Thus, after rod and weight together have fallen a definite distance, the weight is caught by the diaphragm and makes the signal sound, while the rod still continues to fall. On hearing the signal sound the person to be tested presses down a lever, thereby releasing a spring clamp which grips the falling rod firmly. The interval of time between the signal sound and this operation is measured by the space the rod has fallen through, and is read at once in hundredths of a second from graduations on the rod itself.

The third instrument shown—designed at the suggestion of the President—was for measuring the relative sensitiveness of the eye to various colours in different persons. An object, such as a card, on which numbers are printed in diamond type, is fixed