The Origin of the Scale of Fahrenheit's Thermometer.

YOUR issue of February 13 contains, on p. 348, a note on the above subject, in which it is stated that Fahrenheit based his scale upon a scale previously adopted by Newton, Newton's scale having its zero at freezing point and the temperature of the human body marked as 12 degrees. Fahrenheit (says Sir Samuel Wilks) found Newton's divisions too large. He therefore divided them by two. Next he altered his zero to the temperature produced by a mixture of ice and salt. Later on he again divided each degree into four parts, giving the scale which is now in use. This explanation is substantially that which is given in the "Encyclopædia Britannica."

It is evident that the origin of the Fahrenheit scale is a matter of some speculation. A recent work, the "Evolution of the Thermometer," by Mr. H. C. Bolton (reviewed in NATURE of May 9, 1901), states that Fahrenheit's selection of a scale was unfortunate, and did not appear to have been based on anything.

It seems very unlikely that Fahrenheit, who was an accomplished man of science and experimenter, and whose thermometers were acknowledged to be a great advance on others existing at the time, should have based his scale on nothing at all.

An examination of the main features of Fahrenheit's work upon thermometers gives, I think, the key to the origin of the scale, and shows that he based it upon a very sound and scientific foundation. In discussing this question, one must have a regard for the state of the knowledge of kindred matters at the beginning of the eighteenth century, and consider how the problem would be likely to present itself to Fahrenheit.

Reference is made in the note to a paper in the *Philosophical Transactions* for 1701, supposed to have been written by Newton. In this paper, which is written in Latin, is described a scale of degrees of temperature (Scala graduum Caloris) from the freezing point of water to the melting point of gold, but it does not appear that this scale was intended to be actually applied to a thermometer. It seems only to be intended as a convenient scale of reference for comparing temperatures covering a very wide range. The zero or starting point is the freezing point of water. The external temperature of the human body is taken as the second point from which the scale is derived. The range of temperature between these two points is divided into twelve parts. The freezing point is, therefore, called 0, and the body temperature 12. The scale is continued upwards, and it was found that the temperature of water boiling violently corresponded to 34 degrees. Many other degrees are noted as indicating the melting points of metals, &c.

The paper continues with a description of a thermometer, the liquid element of which is linseed oil. The actual scale of the thermometer, however, was not that described above, but was determined as follows:—

The thermometer was placed in melting snow. The space filled by the oil in the bulb and the stem together was taken as occupying 10,000 parts. The same oil, when expanded by the heat of the human body, occupied a space of 10,256 parts, and by the heat of boiling water 10,725 parts. Thus, on this thermometer, if the freezing point was marked 0, body temperature was 256 and boiling water 725. It was by means of this thermometer that the temperatures were obtained from which the "Scala graduum Caloris" was computed.

Fahrenheit is credited with having been the first to use mercury in the thermometer. He also discovered how to produce a temperature much below the freezing point of water by mixing "ice, water and sal-ammoniac or salt."

In a paper (also in Latin) which he contributed to the *Philosophical Transactions* of 1724, on the subject of "Experiments concerning the Freezing of Water," he described his thermometer, but did not explain his reasons for adopting the particular scale. It may be safely assumed that he was acquainted with the paper published in 1701 referred to above.

Having then decided upon the use of mercury in his thermometer in place of the oil previously used, the problem upon what basis his scale should be constructed would next arise. What could be more natural than to base it upon the expansion of mercury itself? The idea of making his degree or unit that difference of temperature by which the liquid expands by one *ten-thousandth part of its volume* would naturally occur to him, for it had already been done in the case of the oil thermometer. That this is the basis of the Fahrenheit scale I think is proved by the fact that for each degree of the Fahrenheit scale mercury *does* expand by one ten-thousandth part of its volume.

Having, therefore, determined upon the size of his divisions or degrees, the next thing was to fix on a zero or starting point. What, again, could be more natural than to start with the greatest degree of cold which he knew how to produce, namely, the temperature of the ice and salt mixture? Having settled upon this, everything else follows, and we have the Fahrenheit scale as we know it to-day. The thermometer registers for freezing point 32°, blood heat 98½°, and boiling point 212°. In his own description of his thermometer, he states that the temperature of the body is 96°, but this slight error was probably due to the thermometer not being properly heated by that part of the body to which it was applied, and in any case does not affect this explanation, which, I think, suggests that the Fahrenheit scale is based upon scientific principles, and is not, as is often supposed, a scale without rhyme or reason.

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The Inheritance of Mental Characters.

I QUITE agree with Prof. Cockerell that further discussion of this subject had better be postponed, if, indeed, it be not wholly unprofitable. But I may, perhaps, be permitted to make three remarks:—

(1) The coefficient of correlation is a measure of the degree of resemblance between brothers. We are told it may be due to "soul," heredity or environment. "Soul," I take it, can only contribute to likeness between brothers, if they have like "souls." If so, I suppose the likeness of "soul" is due to inheritance of "soul," and I do not see how this is going to be distinguished from other forms of heredity. I am not unaware of Dr. Wallace's views on spirit hierarchies. I considered them in my "Grammar of Science," and still hold them thoroughly illogical and unscientific.

(2) What I asked Prof. Cockerell to do was to explain why the intensity in inheritance of mental and physical qualities came out the *same*. He may have views why they ought to be different, but it remains for him to explain why soul + heredity + environment in one case = heredity + environment in the other.

(3) I believe the mental characters in man are far more persistent than Prof. Cockerell credits them with being. The relations between head-measurements and intelligence are almost identical whether we deduce them from young children or undergraduates, and there is no apparent change of correlation when we compare brothers at close and at more distant ages. It is perfectly possible to determine from our data the proportions of children at each age with given mental characters. Prof. Cockerell belongs to those critics who live in the region of "may-be." If he will collect observations on some 5000 to 6000 children as we have done, he may still come down from the region of "may-be" and be able to place fact against fact.

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The Colours of Wings in Butterflies.

YOUR correspondent in India, W. G. B. (NATURE, February 13, p. 344), has been examining a butterfly in some ways like the *Morpho Cypris* of South America, the difference being that the latter has the upper side brilliant and the lower side brown.

The Morpho can be placed so that the two wings on one side of the body are metallic blue, while the other two are black; with a slight turn the two sides reverse colours. This seems to be like the case of the Purple Emperor, in which all edges of the scales facing one way are blue, and other edges are brown. A ploughed field with furrows running east and west might after snow and sunshine appear white from the north and black from the south. In London it is easy to see the Morpho; instead of the furrows it is possible to take for illustration a common form of advertisement.

The Morpho, like the Indian specimen, presents shades of ultramarine, peacock-blue, and sea-green; also in transmitted light the scales are golden. In most cases of coloured surfaces we are not yet able to point out the action on the light waves. Prof. Tyndall showed how small particles in air or water might reflect blue waves and allow the larger red waves to curl round them and go forward; but this does not apply to a surface which reflects the larger waves. It can only be said that coloured surfaces are such as have the power at a minute depth of selecting some waves for reflection; in the case of gold leaf or some butterflies' wings, the remainder of the light may be seen, transmitted almost without any loss by absorption, as the thickness traversed is so