in these infra-red photographs of coloured men, though neither is of racial significance (Fig. 1). Owing to the general lightening of colour, even the darkest eyes appear light; their irides as seen in the infra-red print appear of the same colour as blue-grey eyes in normal photographs. The other peculiar feature is that it is often possible to trace the appearance of a beard and moustache in prints of clean-shaven men, due to the human skin having its maximum transmission in the region of the infra-red, so that the hair follicles with their contained hair shafts show up as darker shading.

FIG. 2. Photographs with panchromatic (left) and infra-red (right) materials of a white girl (Nordic type); hair, very fair; eyes, blue-grey; complexion, very fair; wearing blue and white striped jumper.

In the photographs of the white race, relatively few in number, some of these results are reversed (Fig. 2). There is the same waxy pallor of the skin in the infra-red prints, and freckles are obliterated, but the eye colour changes in the opposite sense. Instead of being lightened, eyes described as blue appear dark, so as to suggest deep hazel or medium brown. On the other hand, in an infra-red print of a man whose eyes are described as brown, the irides are if anything a shade lighter than in the normal photograph, thus approaching the lightened colour of infra-red prints of the eyes of the dark races. The normally dark eyes of a Japanese appear in the infra-red print about the same shade as the blue-grey eyes of a typical Nordic. In Europeans the less dark shades of hair may appear considerably lightened, just as the leaves of trees present a white, almost frosted, appearance in infra-red photographs.

To sum up: the differences in the normal and infra-red photographs of the varieties of *Homo*, though striking at first sight, do not appear to present any features likely to be of use to the anthropologist; they are, indeed, of photographic rather than anatomical interest.

Heavy Hydrogen*

By SIR J. J. THOMSON, O.M., F.R.S.

THIS lecture is on reminiscences connected with the Royal Institution, so that accounts of quite recent discoveries would not be within its scope. There is one subject, however, which is now attracting a good deal of attention—heavy hydrogen—which satisfies both conditions; it is a reminiscence and it is connected with the Royal Institution. In 1911 I gave a Friday evening discourse "On a New Method of Chemical Analysis". By this method each kind of gaseous particle in a vessel through which an electric discharge is passing produces its own parabolic curve on a photographic plate. Thus if the vessel contained a mixture of hydrogen, oxygen and nitrogen, there would be six parabolas corresponding to the atoms and molecules of hydrogen, oxygen, and nitrogen respectively, along with others due to each of the compounds formed by these elements. The mass of the particle which produces any parabola can be determined from the position of the parabola.

Using this method, I detected the presence of a parabola which must have been produced by a particle of mass 3 (the mass of the hydrogen atom being taken as the unit). I obtained it first when the gas in the discharge tube was hydrogen prepared in the ordinary way, but its appearance was very capricious, and only occurred in a small percentage of the experiments. I found, however, that if instead of using ordinary hydrogen, I used the gas given off by certain solids when bombarded with cathode rays, the (3) parabola appeared with great regularity. The amount of the gas producing it varied with the nature of the solid bombarded, but there were few minerals or salts among those I tried which did not give traces of it; potash (KOH) is a very convenient source and a specimen of black mica given to me by Sir James Dewar gave an exceptionally large supply.

I obtained the active gas also by deflagrating a very thin wire by passing a very large current through it, or even by raising a wire to bright incandescence. This indicates that the bombardment by cathode rays does not manufacture the gas but merely liberates it from the solid.

I made a very large number of experiments on the gas obtained in this way, the results of which were published in the *Philosophical Magazine* and summarised in my book "Rays of Positive Electricity" (Longman). One important property of this gas is that it can be stored after bombardment and tested long after it has been produced, showing

* From a Friday evening discourse delivered at the Royal Institution on February 9.

that it is a stable gas and can exist in an uncharged state. In fact, the persistence with which it clings to the walls of the discharge tube and the cathode makes experiments troublesome, as when once the tube has been used for this gas, it will continue, after the gas has been pumped out and replaced by another of a different kind, to show the (3) parabola; long sparking with oxygen in the tube is required to get rid of it.

I made many tests of the chemical properties of this gas and found that under them it behaved like ordinary molecular hydrogen. Thus, for example, it disappeared after vigorous sparking in the presence of oxygen, or when passed slowly over red hot copper oxide; again like hydrogen it can pass through red hot palladium; and there was evidence that when an electric discharge was passed through it, some of its molecules were split up into a positively charged hydrogen molecule and a negatively charged hydrogen atom.

Through the kindness of Lord Rutherford, I have had the opportunity of examining by the positive ray method samples of 80 per cent concentration of heavy hydrogen prepared by recent methods. Very interesting photographs obtained with heavy hydrogen of less concentration have been published by Prof. P. Zeeman. So far as I can see, the heavy hydrogen behaves in just the same way as the form of hydrogen obtained by bombarding solids. With these high concentrations, so much heavy hydrogen adheres to the walls of the tube, that instead of trying to get rid of it by bombarding with oxygen, it saves time to make a new tube for each experiment. Again, with the highly concentrated gas, I found, as Prof. Zeeman had done, parabolas corresponding to H_4 and H_5; in my early experiments a parabola (4) was frequently seen along with H_3. I ascribed it to helium and probably some of it was due to this source, but now I think part of it was due to H_4; on a few occasions, too, I observed a line corresponding to H_5. The evidence seems to me to leave little doubt that the gas I called H_3 more than twenty years ago is the same as that which is now called heavy hydrogen.

I said in "Rays of Positive Electricity" that from my experiments I suspected that there might be two kinds of H_3; this surmise is confirmed by the fact that many chemists who have experimented on tri-atomic hydrogen have come to the conclusion that it has a life of only a minute or so, and can only exist when charged with electricity. So far as I know, they all used hydrogen prepared in the usual way and not that obtained by bombarding solids; there is not the slightest doubt that the H_3 obtained in this way is stable and can exist uncharged.

I think the effect of the solid is due to its adsorbing a mixture of gases including H_2 and H_3, and that when it is bombarded, relatively more H_3 than H_2 comes off from the adsorbed layers. Thus the mixture that comes out is richer in H_3 than the mixture in the gas adsorbed by the solid.

Obituary

SIR WILLIAM HARDY, F.R.S.

THOSE who enjoyed Hardy's friendship, and even those who could hope for no more than occasional contact with him, will deeply feel the loss of a strong and vital personality radiating an influence which stimulated effort, cured discouragement and could reawaken flagging enthusiasms. Hardy entered into everything he did with zest, and this seems to be the word which adequately describes his own attitude to life. He met each successive experience with fresh interest, and brought his whole nature to the appreciation of whatever it offered of value. His enjoyment of intellectual pleasures was itself almost sensuous, while his delight in the beauties of Nature, or in the appeal of fine pictures and music, was always mingled with—and, for him, intensified by—the intellectual reactions they evoked. Life's minor pleasures appealed to him and he loved a good wine, and a good story, in the telling or the hearing, and he enjoyed both best in good company.

Surpassing Hardy's many other enthusiasms was —as all his friends knew—a passion for the sea and the adventures it provides for all good sailormen like himself. Research stood high among his pleasures; he would literally smack his lips over some happy occurrence in a test tube, but probably the highest note in the gamut of his enjoyment was evoked by a boat with full sails, a spice of danger, and with the good ship answering to his hand on the helm.

Some insistence upon this lusty side of Hardy's temperament is essential to any proper understanding of him as a man; but while he savoured all pleasures so keenly, his outlook was far indeed from that of the mere hedonist; his life was full of serious purpose, and no less full of accomplishment and service.

I myself came first to know Hardy in 1898, when he was in his thirty-fourth year. His scientific training had been that of a biologist, and at this time he was on Michael Foster's staff in the Physiological Laboratory at Cambridge. He was, in particular, responsible for the teaching of histology to the advanced class, and had engaged in histological research. He had published, alone and with others, several papers describing highly original work on wandering-cells, and *inter alia* on the nature of the attack of oxyphil blood cells on bacteria.

Just before I became a member of the Cambridge staff, Hardy had convinced himself that current histological methods were employed with too little discrimination, and that many of the structures supposed to be characteristic of protoplasm were no more than artefacts produced by the action of