constant d, that is, if d means, not the true distance d_0 between the reflecting planes but a corrected value

$$d = d_0\left[1 - \frac{4d_0^2}{n^2}\frac{\delta}{\lambda^2}\right],$$

where δ has the value known from the ordinary dispersion-theory:

$$\delta = \frac{e^2}{2\pi c^2 m}\sum_{i=K,L,M\,..}\frac{N_i}{\nu^2 - \nu_i^2},$$

and ν_i are the natural frequencies of the K, L, M, etc. electrons.

On passing one of the natural frequencies, the value of d apparently undergoes an abrupt variation quite in accordance with the experimental results.

It may be noticed that the graph is not a simple dispersion-curve, as it gives the relation between *two* such curves, namely, that of gypsum to that of calcite. The discontinuity at calcium is due to the fact that the relative number of the K-electrons of this element per unit volume is different at the two crystals.

This result shows that it is necessary in all accurate measurements of X-ray wave-lengths to use a corrected Bragg formula for the calculation of the wave-lengths from the angles of reflections. For this purpose, the first condition is to know the dispersion formula of the crystal for X-rays. Such an investigation may be carried out with the ordinary prism-method applied for X-rays, as shown in a communication from this laboratory (*Die Naturwissenschaften*, December 26) or with the method given by Bergen Davis and his collaborators.

ELIS HJALMAR.
MANNE SIEGBAHN.

Fysiska Institutionen,
Upsala Universitet,
December 12.

Scattering and Absorption of γ-Rays.

IN a recent letter to NATURE (January 3, p. 13) I have stated that, on current theories, it is exceedingly difficult to account for the results of experiments on the scattering and absorption of hard γ-rays. I should like to add to this statement that a reasonable explanation of such results has since been obtained by means of the following assumptions, for which there is a certain amount of evidence:

1. The secondary β-rays produced in light elements by hard γ-rays are practically all recoil electrons.
2. The photoelectric or fluorescent absorption coefficient of γ-rays varies as the cube of the wave-length.
3. The hard γ-rays of radium-C behave in the same manner as would a mixture of two types of wave-lengths 0·024 and 0·008 Å.U. respectively, each type having about 50 per cent. of the total energy.
4. The number of quanta scattered per unit area at an angle θ varies as $(1+\cos^2\theta)/(1+2\alpha)$, where $\alpha = h\nu_0/mc^2 = 0\cdot0242/\lambda_0$, h being Planck's constant, ν_0 the initial frequency, m the mass of an electron, c the velocity of light, and λ_0 the initial wave-length.

With the angular distribution of "scattered" quanta proposed above, the average energy of a recoil electron, for values of $\alpha > 1$, approaches closely the maximum energy E_M which equals $2\alpha h\nu_0/(1+2\alpha)$. Further, as α increases, the total energy of the recoil electrons becomes a greater and greater proportion of the energy lost by the scattering process, *e.g.* when $\alpha = 3$, the total energy of the recoil electrons is equal to twice the energy of the scattered γ-radiation. These are the reasons why one can account for the observed energy of the secondary β-rays when it is assumed that a large proportion of the total γ-ray energy is of the softer type, it being necessary to assume that this type is present in order to account for the observed values of the fluorescent absorption coefficient.

It might be mentioned that, with distributions of scattered quanta hitherto proposed, the average energy of a recoil electron is about $\frac{1}{2}E_M$, and the total energy of the recoil electron is always less than that of the scattered γ-radiation.

I believe it can be shown, from what has been proposed above, that γ-rays must have a "range"; *i.e.* for rays of any one wave-length, there could be a certain thickness of material, through which the rays would not pass, no matter how great the initial intensity. This would indicate that the scattering of γ-rays is a scattering of "corpuscles," a view which I referred to and rejected in a former paper (*Phil. Mag.*, p. 611, 1913).

In my letter of January 3, p. 13, it is stated that, "Taking the average energy of such a β-ray to correspond to 467,000 volts, . . . a simple calculation shows that only one in every five radium-D atoms emits a γ-ray on disintegration." The figures should have been 333,000 volts and only one in every seven radium-D atoms emits a γ-ray on disintegration.

J. A. GRAY.

Queen's University,
Kingston, Ontario.

Spermatogenesis of *Succinea ovalis*, Say.

AN investigation of the spermatogenesis of *Succinea ovalis*, Say., a small terrestrial pulmonate of North America, has revealed the following:

1. Forty chromosomes are found in the spermatogonial divisions, and twenty in the maturation divisions.
2. Typically of all pulmonates so far studied, there are two centrioles, proximal and distal. Early in spermogenesis the proximal centriole penetrates through the nucleus of the spermatid, and with the surrounding intranuclear canal, forms an intranuclear rod in very much the same way as has been reported for certain prosobranchs.
3. Both the head and tail of the spermatozoon have a spiral twist. These spirals go in either a clock-wise or counter clock-wise direction, one type being about as common as the other.

Of the cytoplasmic structures, the mitochondria and the Golgi apparatus were followed through all stages of spermatogenesis.

The mitochondria are seen in the early primary spermatogonia as small masses of granules lying near the nuclei. They increase in size and number in the primary spermatocytes, and at each of the maturation divisions they are distributed approximately equally between the daughter cells. Some of the granules go to form the sheath of the axial filament of the spermatozoon, while the rest are sloughed off with the cytoplasmic balls.

The Golgi rods cannot be identified with certainty in the primary spermatogonia. In the primary spermatocytes they occur as conspicuous banana-shaped rods grouped closely around the idiosome; 15-20 rods can be counted in these stages. During dictyokinesis there is no fragmentation of individual rods, but they are distributed intact to the daughter cells. 3-5 rods are found in the spermatids. In the final ripening of the spermatozoon, the apparatus is seen in the cytoplasmic balls as faintly-staining, disintegrating bodies.

A more detailed account will be published later.

CLEVELAND P. HICKMAN.

Department of Biology,
Princeton University, U.S.A.,
November 26.