but when the interval was fifteen or more seconds, they were produced in greater number. The conclusion deduced from these and similar experiments with nitrate of potash was, that impregnation is commenced almost at the instant of contact of the spermatozoon with the ovum; but that duration of contact, and possibly also diffluence of the spermatozoon and endosmosis of its substance, is necessary for fruitful impregnation. The experiments were varied by the application of the solution of potash before that of the seminal fluid, in which case the results were more unfavourable. With nitrate of potash, applied before as well as after the seminal fluid, the formation of embryos was not unfrequent. None however were produced when diluted acetic acid was used. This acid acts quickly and most unfavourably on the envelopes of the ovum.

The agency of the impregnating bodies was then tested in a similar way, by the application of solutions of gum-arabic and of starch, the action of which is merely mechanical. The results were similar to those with the potash.

When the gum or starch was applied, as in the case of the potash, *after* the application of seminal fluid in water, embryos were constantly produced, even when the interval between the two applications was only one second; but when either of these was applied to the ovum *before* the seminal fluid, then segmentation, if it occurred at all, took place very tardily. In general, however, no segmentation occurred, and no embryos, or but very few indeed, were produced.

These experiments, compared with those with potash, seemed to show that impregnation is commenced in a very short space of time, and that the spermatozoon is the agent immediately concerned; and that this agency is material in its operation, as seems to be shown in the fact that it can be prevented by the application both of chemical and of mechanical means to the ovum. We are thus led to infer, that although the spermatozoon does not bodily penetrate into the ovum, its first effect may have some relation to catalytic action, in inducing the segmentation of the yelk; and, having proof that fluids permeate the coverings of the ovum, we may hereafter find that the process is completed by the diffluence of the impregnating body, and the substance into which it is dissolved, by imbibition into the ovum by endosmosis.

One plate of the structures described accompanies the paper.

8. "A Mathematical Theory of Magnetism." By William Thomson, Esq., M.A., F.R.S.E., Fellow of St. Peter's College, Cambridge, and Professor of Natural Philosophy in the University of Glasgow.

The Theory of Magnetism was first mathematically treated in a complete form by Poisson. Brief sketches of his theory, with some simplifications, have been given by Green and Murphy in their works on Electricity and Magnetism. In all these writings a hypothesis of two magnetic fluids has been adopted, and strictly adhered to throughout. No physical evidence can be adduced in support of such a hypothesis; but, on the contrary, recent discoveries, especially in electro-magnetism, render it excessively improbable. Hence it is

of importance that all reasoning with reference to magnetism should be conducted without assuming the existence of those hypothetical fluids.

The writer of the present paper endeavours to show that a complete mathematical theory of magnetism may be established upon the sole foundation of facts generally known, and Coulomb's special experimental researches.

The first part of the paper contains a general theory of magnets; the theory of magnetic induction, or of magnetization being reserved for communications which the author proposes to offer subsequently to the Royal Society. The five chapters which have already been communicated bear the following titles:—

CHAP. I. (§§ 3—20). Preliminary Definitions and Explanations.
CHAP. II. (§§ 21—31). On the Laws of Magnetic Force, and on the Distribution of Magnetism in Magnetized Matter.
CHAP. III. (§§ 32—44). On the Imaginary Magnetic Matter by means of which the Polarity of a Magnetized Body may be represented.
CHAP. IV. (§§ 45—64). Determination of the Mutual Actions between any Given Portions of Magnetized Matter.
CHAP. V. (§§ 65—84). On Solenoidal and Lamellar Distributions of Magnetism.

In the second chapter the method of specifying, by "intensity and direction of magnetization" at every part of it, the magnetism of a magnet, is given; being founded on the elementary phenomena, and Coulomb's laws of magnetic force, which are explained in Chap. I. and the beginning of Chap. II.

In the third chapter, by a strictly synthetical investigation, corresponding closely with that investigation of "the equation of continuity" in fluid motion which is analogous to Fourier's investigation of the equation of motion of heat in a conducting solid, a certain distribution of "imaginary magnetic matter" consisting of equal quantities of positive and negative, or northern and southern matter each occupying finite portions of the body or of its surface separated from those occupied by the other, is shown to represent the polarity of a magnet according to the assumed properties of this magnetic matter. The formulæ by means of which the resultant action between two entire magnets of finite dimensions is determined are much simplified by this conventional method of representing polarity. The result of the investigation agrees with what is expressed by a certain formula of Poisson's, deduced by a process of *integration by parts*, from his elementary expression for the function since called by Green the "potential," at any point in the neighbourhood of a magnet. Hence the investigation of Chap. III. leads, as is shown at the commencement of Chap. IV., to a strictly synthetical proof of that remarkable formula.

The fourth chapter contains, in the first place, formulæ for the "potential," and for the "magnetic force," at any point in the neigh-

bourhood of a magnet, which agree with those of Poisson; and secondly, formulæ for the resultant action experienced by any finite portion of magnetized matter placed in a "field of force," either given, or determined by the preceding formula from a specification of the magnets to which it is due, by which the mathematical treatment, according to one method, of the problem which forms the subject of the chapter is completed. The chapter is concluded with the statement of a method of expressing the mutual action between two magnets by means of the differential coefficients of a function of their relative position, which is of importance chiefly because the principles on which it is founded lead to a new field of investigation in the theory of magnetism, having for subject the "mechanical value of magnetic distributions."

The fifth chapter contains, in the first place, explanations of the principal properties of the peculiar distributions to which the author has given the names of *solenoidal* and *lamellar*. A solenoidal distribution may be briefly defined as one of which the *polarity*, or the representative *imaginary magnetic matter* is entirely superficial; and a lamellar distribution, as one of which *the representative galvanism*, or the *resultant equivalent electrical currents*, are entirely superficial. If α, β, γ be the components of the intensity of magnetization at any point x, y, z of a magnet, the condition that the distribution of magnetism may be solenoidal is expressed by the equation

$$\frac{d\alpha}{dx}+\frac{d\beta}{dy}+\frac{d\gamma}{dz}=0;$$

and, again, the condition that the distribution may be lamellar is expressed by the three equations

$$\frac{d\beta}{dz}-\frac{d\gamma}{dy}=0,\quad \frac{d\gamma}{dx}-\frac{d\alpha}{dz}=0,\quad \frac{d\alpha}{dy}-\frac{d\beta}{dx}=0.$$

In the concluding part of Chap. V. three new methods of analysing the action of a magnet, suggested by the consideration of these special forms of distribution, and constituting, with Poisson's method mentioned above, a system of four expressions for the magnetic force connected with one another by certain analogies, are given. One of these (Poisson's) expresses the force at any point in terms of double integrals for the surface (the components of the force due to the superficial polarity); and triple integrals for the whole interior, involving $\frac{d\alpha}{dx}+\frac{d\beta}{dy}+\frac{d\gamma}{dz}$, and vanishing when this vanishes, *i. e.* when the distribution is solenoidal. The analogue of this expresses the force in terms of double integrals for the surface (the components of the force due to the superficial representative galvanism) and riple integrals for the whole interior, involving

$$\frac{d\beta}{dz}-\frac{d\gamma}{dy},\quad \frac{d\gamma}{dx}-\frac{d\alpha}{dz},\quad \frac{d\alpha}{dy}-\frac{d\beta}{dx},$$

and vanishing when these vanish, *i. e.* when the distribution is lamellar. Of the two remaining methods, one is confined to solenoi-

dal distributions, and expresses the magnetic force at any external point, or at any internal point in an infinitely small crevass tangential to the lines of magnetization, as the resultant of a certain distribution of tangential magnetization in an infinitely thin shell, coinciding with the surface, and occurred to the author as the analogue of a method which he had long before found for expressing the force due to a lamellar distribution. In this last-mentioned method, which is confined to lamellar distributions, the force at any external point, or at any interior point in an infinitely small crevass perpendicular to the lines of magnetization, is expressed as the resultant of a certain distribution of normal magnetization in an infinitely thin shell coinciding with the surface.

9. "Les Causes du Magnétisme terrestre prouvées." Par M. Pierre Beron. Communicated by John Lee, Esq., LL.D., F.R.S. &c.

The author considers the elements of terrestrial magnetism to be, that the force with which the magnetic needle maintains its position is not everywhere the same, and that its declination and inclination vary from one region to another. These elements, he states, undergo very different modifications, which may be reduced to the following:—

1. Variations with reference to the position of the sun to the south or to the north of the equator; 2. diurnal variations in different regions of the earth; 3. disturbances which proceed from changes of weather, and from volcanic irruptions, and those which are observed during the appearance of the aurora borealis; 4. secular variations.

Adopting the views which have long since been put forward, but without adverting to the opinions of others who have preceded him in the same path, the author refers all the phænomena of terrestrial magnetism to the action of thermo-electric currents, and states, that as we know from climatology the regions of the earth which have the most hetero-thermal seasons, we have data for determining the intensity and direction of the thermo-electric currents in every region of the globe.

The hetero-thermal regions being marked by the isothermals of the most hetero-thermal months, the author distributes the thermo-electric currents into four magnetic systems, in each of which the currents are directed towards the middle, marked by the culmination of the isothermals. He then endeavours to trace out the general connexion between the thermo-electric currents which he assumes and the magnetic phænomena as observed in what he terms the American, the Asiatic, the Australian, and the Gallipagos' magnetic systems.

The extraordinary disturbances in the direction of the needle, he attributes to changes in the regular order of the distribution of solar heat, which give rise to corresponding changes in the thermo-electric currents; and the secular variation to the amelioration of climate arising from the culture of the soil in different regions of the earth.

The author concludes his memoir with the following remark:—