XXXII. On the cause of endosmose and exosmose

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visible for an hour and a half. On the 23rd the sky was very clear, the air calm, the meteor less brilliant than the evening before; it was seen suddenly on the horizon at a quarter past seven, and did not disappear till thirty-five minutes past eight. Lastly, on the 28th, the Bise was strong, and fleecy clouds were perceived around the luminous band, which lasted until forty-two minutes past eight. It appears certain that it was always seen single, vertical, and with parallel edges.

Lausanne, June 30, 1846.

XXXII. *On the Cause of Endosmose and Exosmose.*

By GEORGE RAINEY, M.R.C.S.*

THE phenomena of endosmose and exosmose were attributed by Dutochet to the passage of currents of electricity of unequal intensity through a membrane situated between two fluids of different densities, these currents being supposed to carry with them unequal quantities of fluid. Although the facts of endosmose and exosmose, as described by this philosopher, are admitted by all to be correct, yet his explanation of them has not been generally received; nor am I aware that they have ever been explained in a manner generally satisfactory, and therefore I shall be obliged if you will insert in your valuable journal the following explanation.

It is a fact which probably no one will question, that when two fluids of unequal density are brought into contact in minute quantities, without any membrane being interposed, they will intermix by diffusion, the rarer fluid intermingling itself with the denser one, and the denser fluid diffusing itself through the rarer one, until the one becoming gradually more dense, and the other less so, the whole mass acquires one uniform consistency. However, should this fact be doubted, it can be well illustrated by introducing between two surfaces of glass, placed almost in contact, some thick mucilage, and a little thin coloured fluid of any kind, for instance common writing-ink, and observing with the microscope the part where they become united, when the two fluids will be seen gradually to intermix, and to become so blended together, that their line of union will become lost.

The same fact can be shown by introducing some mucilage into a piece of thermometer tube, and after it, at the same end, some writing-ink. The coloured fluid will at first pass only in a small column through the mucilage, along the centre of the tube, leaving the mucilage in contact with its parietes, but afterwards they will become gradually blended together.

* Communicated by the Author.

Also by filling a piece of thermometer tube with water, closing its upper extremity, and placing it vertically with its lower one in a solution of gum coloured with logwood, when the latter will gradually ascend and colour the former, showing that the diffusion is independent of gravity, and therefore may be inferred to be the result of that attraction which is exerted universally between the particles of matter, varying in the inverse ratio of the squares of their distances, and in the direct ratio of their masses; the particles in this instance, upon which the difference of density of the two fluids depends, being contained in a medium which allows of their free motion one upon another, cannot therefore come to a state of rest until every one of them is attracted equally on all sides, that is, until all the fluid is of one density. It is also a fact equally unquestionable, that if solutions of the same substance in the same menstruum, but of different densities, be filtered through the same membrane, the more rare fluid will pass through it with greater rapidity than the denser one. This is one of the effects of the same principle of attraction, the dense fluid being in this case more strongly attracted by the material of which the membrane is composed than the rare one.

Now, when two fluids of different densities are separated by a porous membrane, the porosities being merely a multitude of capillary tubes, like the space between the pieces of glass, or the tube of the thermometer, will allow of the passage through them of the particles of one solution into the other; and they will become mixed together by diffusion the same as if no regular membrane were present, as in the experiments just detailed; so that electricity may just as well be regarded as the cause of diffusion as of endosmose, these being the same. However, the membrane being traversed by an immensity of extremely minute porosities, will extend the surface of the two fluids between which it is placed, and in this way, bringing into close proximity a great number of particles, place them under circumstances very favourable for the operation of the force of attraction of one particle for another. But the characteristic feature of endosmose and exosmose is, that the rarer fluid passes through the interposed membrane more rapidly than the denser one; and therefore that an accumulation takes place on that side of it on which the latter was placed. The reason of this is obvious; for had it been otherwise, or even had these quantities been equal, then the rarer fluid must have repassed through the interposed membrane, after its density had been increased by its intermixture with the denser fluid, as rapidly as it passed through it before its density had been thus augmented; or from the commence-

ment of the operation the dense fluid must have passed with the same velocity through the membrane as the rare one, which is contrary to the second fact. Therefore, in case of diffusion of two fluids of unequal densities through a porous partition, the fluid must *accumulate* on that side of the partition on which is situated that fluid which passed through it most slowly.

This explanation is applicable in all cases in which the rarer fluid on the one side of the membrane has the same chemical properties as that on the other side, their difference being only in their degree of density.

If these fluids be dissimilar in respect to their chemical qualities, still the accumulation will take place on that side of the membrane on which was situated the fluid which passed through it most slowly, although its density may be less than the other; thus, for instance, when a bladder full of air is surrounded with carbonic acid, the latter enters faster than the former escapes, and the bladder bursts. Now it is found by experiment, that carbonic acid passes through wet membrane quicker than atmospheric air, although of a greater density.

In such instances the relative velocities of the passage of different fluids through membrane will be influenced by their chemical attraction for the material of which the membrane is composed, as well as by that attraction which is regulated by quantity of matter; and in some cases the existence of the latter force may be so modified by the former as to be wholly inappreciable; but still that force, being an universal agent, and acting upon all matter according to invariable laws, is in operation in every instance where the conditions requisite for endosmose and exosmose are present, although in some cases chemical attraction or electricity may have no demonstrable existence; and therefore it may be looked upon as the essential cause of endosmose and exosmose, chemical affinity, electricity, &c. being merely the modifiers of its operation, and in respect to it, secondary agents.

XXXIII. *On some Formulæ which serve to indicate the limits of the application of Indeterminate Methods to the solution of certain Problems.* By JAMES COCKLE, M.A., of Trinity College, Cambridge*.

THE equations distinguished below by unaccented numbers will respectively be found at p. 344, or one of the four succeeding pages, of the Report of the Sixth Meeting of

* Communicated by Sir George Cayley, Bart.