two discharges which have been mentioned. Nor is it difficult to find a reason for the rest which follows the tetanus when cathelectrotonus is established, and the momentary contraction which happens when cathelectrotonus passes off. The rest which follows the tetanus under these circumstances is intelligible; for the cathelectrotonus may be supposed to do away with the power of responding to the action of the salt; and the momentary contraction which happens when the cathelectrotonus passes off is intelligible also; for, according to the premises, the cessation of the state of electrotonus implies the cessation of a state which counteracts that action of the salt which causes contraction. Moreover, it is intelligible enough that there should be tetanus after anelectrotonus, and momentary contraction only after cathelectrotonus, if the power of contracting be impaired in the one case and preserved in the other.

Nor is it otherwise with other experiments on electrotonus when care is taken to eliminate what is fallacious.

One and the same explanation, indeed, would seem to apply to the motor phenomena connected with anelectrotonus and cathelectrotonus, and to the motor phenomena connected with the inverse and direct currents; and this explanation is to be found, as it would seem, in the workings, not of the constant current, but of statical electricity.

The electrotonic variations in the conductibility of nerve detected by Professor von Bezold are reserved for future investigation.

April 15, 1869.

Lieut.-General SABINE, President, in the Chair.

The following communications were read:—

I. "On the Source of Free Hydrochloric Acid in the Gastric Juice." By Professor E. N. Horsford, Cambridge, U. S. A. Communicated by T. Graham, F.R.S. Received January 18, 1869.

The long-disputed position of Prout that the gastric juice contains free hydrochloric acid, was at length established by C. Schmidt, who, in an absolute quantitative analysis of the juice, found about twice as much hydrochloric acid as was required to neutralize all the bases present. The prolonged discussion of this subject (now since 1823) has brought to light, through the researches of Lassaigne, Tiedemann and Gmelin, Berzelius, Blondlot, Claude Bernard, Schwann, and numerous others, the unmistakeable evidence of the presence of lactic acid and of acid phosphates in the gastric juice, which latter might or might not be due to the presence of lactic or hydrochloric acid. A point of special interest to the chemist and physiologist still remained, and was this:

How could free hydrochloric acid be secreted from the blood, which is an alkaline fluid?

The blood freshly drawn consists of a fluid (the plasma) in which there are swimming myriads of exceedingly minute irregularly spheroidal bodies (the corpuscles). The plasma consists of two bodies, one of which, the fibrine, spontaneously separates from the other, the serum. The corpuscles are little sacs of delicate animal membrane enclosing a fluid. This fluid has an acid reaction, and its ash contains a monobasic alkaline phosphate. The fibrine of the plasma contains, according to Virchow, a glycero-phosphate of lime, though the plasma, as a whole, has an alkaline reaction, and contains in its ash a great measure (11 per cent.) of chloride of sodium.

The moist corpuscles constitute about one-half of the blood.

I assume that in healthy digestion, as a consequence of increased flow of blood to the gastric mucous membrane and of the normal elasticity of the walls of the capillaries, there exists in the membrane a condition which is the equivalent of engorgement. Under the pressure which attends this condition, the corpuscles in contact with the walls of the capillaries would discharge a portion of their acid contents, which, with the adjacent plasma, would pass through the walls of the capillaries. This mixture would contain acid phosphates and chlorides.

The mucous membrane of the stomach presents on its inner surface the mouths of numerous microscopic tubes, which, like stockings, are sometimes single blind sacs, or, like gloves, terminate in several blind sacs like the glove fingers. In the bottoms of these tubes, and along their sides, are several closed spherical sacs or cells, containing other lesser sacs and fluid within. The tubes, as a whole, dip down into the spongy tissue that underlies the mucous coat, where they are surrounded by the fluid poured from the network of nutritive capillaries, which fluid, as remarked above, contains acid phosphates and chlorides.

Now by pressure and osmosis a portion of this fluid will pass through the walls of the gastric tubes, and the question is:

Whether the fluid that goes through will contain free hydrochloric acid?

The experiments I have made are conclusive on the principal point.

By employing acid phosphate of lime and common salt I had this advantage, that as increased acidity on the one hand is a just inference from increased alkalinity on the other, and as increased alkalinity would be shown by the precipitation of phosphate of lime (a visible white powder) I could determine the qualitative fact without the difficulties and delay attending on accurate quantitative analysis of the solutions, before and after the experiments on both sides of the membrane.

I employed an acid phosphate of lime of specific gravity 1·117, of a constitution of $3(CaO\,P_2O_5)+2P_2O_5$, with an amount of phosphate of peroxide of iron present as one to twenty-eight of the acid phosphate of lime. The various other solutions employed were the ordinary laboratory reagents.

On adding ammonia in small quantities to the solution of acid phosphate,

with alternate agitation, it required, as might be inferred, several repetitions before the peroxide with its phosphoric acid became a permanent precipitate, and still several more before the precipitate of phosphate of lime became permanent.

In my earlier experiments, in which I employed parchment-paper, I was embarrassed with the presence of sulphate of lime in the precipitated powder; so that what was at first supposed to be phosphates of lime and iron was found to be in part sulphate of lime. This sulphate was due to imperfectly washed parchment-paper, which still contained sulphuric acid. This difficulty overcome, the experiments were made with parchment-paper prepared from German and Swedish filter-paper, as well as with goldbeater's skin (animal membrane).

I employed acid phosphate of the formula above, with (each by itself) chloride of sodium, chloride of ammonium, chloride of potassium, chloride of calcium, and chloride of magnesium.

I also experimented with acetate of potassa and acid phosphate of lime.

With all of these there was obtained the same kind of evidence of increased acidity on one side and of increased alkalinity on the other, to wit, the powder thrown down from the mixture of acid phosphate and chloride. What successive additions of ammonia had been required to effect, had been accomplished by dialysis.

The same effect took place from a mixture of acid phosphate of soda and chloride of calcium.

It follows from the above, if these experiments fairly represent the case, and from the known composition of the blood, its condition in the walls of the stomach, and the structure of the gastric tubules, that free or uncombined hydrochloric acid must find its way into the bottoms of the gastric tubules, and thence into the cavity of the stomach.

It may be urged that I should show that the acid phosphate pressed from the corpuscles more than neutralizes the alkalinity of the plasma present. In reply it may be said that I present a condition of things in which there is the *kind* of physical change required *going on*, namely, relative augmentation of the corpuscles, under pressure, the concomitant of increased supply of blood to the gastric mucous membrane. Its degree must be inferred from the effects on the secretions, which I have endeavoured to point out, by conducting an experiment under what I conceive to be essentially like conditions, and obtaining the result due to *identical* conditions.

The secretion of hydrochloric acid is of course mixed with acid phosphates and alkaline chlorides.

That such a result as I have arrived at would follow experiment might have been predicted from Graham's researches on dialysis. Phosphates of lime and soda are colloidal relatively to more crystalloidal hydrochloric acid. Graham found that bisulphate of potassa, by dialysis, was resolved into two salts or mixtures of greater and lesser acidity than the original bi-

sulphate. So he found that acetate of peroxide of iron was resolved by dialysis into hydrated peroxide of iron and free acetic acid. It is possible and probable that the albuminoid bodies present take part in determining the contrast between colloid and crystalloid bodies. Graham found that by dialysis he could separate free hydrochloric acid from the gastric juice thrown up in vomiting.

It may be further objected that anatomists are not agreed as to the structure of the corpuscles. But it will be seen that there is no more required than may be regarded as established. The corpuscles act in many particulars, if not in all, as if they were membranous sacs more or less distended with fluid. They may be swollen by immersion in a thinner (less colloid) fluid, and reduced by immersion in a more colloid fluid—that is, they are susceptible of endosmosis and exosmosis as membranous sacs would be. In their ordinary condition as seen under a microscope, they present the appearance of collapsed spherical or oval sacs or cells. They appear as double concave disks. In swelling (by endosmosis) the lowest part of each concavity is the last to take on the spherical contour, just as it would do if the corpuscles were membranous sacs. The corpuscles sometimes so collapse (by exosmosis) that one-half of the hollow sphere is reversed, while the other half retains its form unchanged, the former sitting like a cup in the latter—a conformation inconceivable on the theory of homogeneity of the corpuscles as a whole. Crystallizable substances may be extracted from the corpuscles by pressure and by endosmosis. They must have been in solution in order to crystallization, and solution involves a fluid. The liquid expressed from the corpuscles has an acid reaction, and contains an organic acid and acid phosphates. It contains, among other bodies, the hæmatoidin of Virchow. The ash of these crystals consists almost wholly of metaphosphates*, which point directly to tribasic phosphoric acid in solution, combined with one atom of fixed base, which is inconceivable unless separated by membrane from the plasma, which is always alkaline.

In fine, whatever other peculiarities the blood-corpuscles may possess, they have the requisites for furnishing acid phosphates in solution under pressure, such as must attend engorgement of the capillaries in the walls of the stomach.

Let us glance at what takes place in all probability as the acid fluid enters the gastric tubules. They are surrounded by a mixture of hydrochloric acid, acid salts, neutral salts, and albuminoid bodies. Dialysis must be repeated, and a stronger acid solution pass into the sacs or cells contained in them. The sacs swelling by endosmosis, and corroded by the acid, must at length burst, and the liquid contents, together with the disintegrated and partially digested membrane of the sacs, pass out into the

* The ether-extract of the blood-corpuscles yields, according to Schwann, an ash containing acid phosphate of soda. Owen, Rees, and Berzelius maintained the existence of oleo-phosphoric acid in the corpuscles.

stomach, to constitute the gastric juice, the free hydrochloric acid, acid phosphates and chlorides, and the albuminoid bodies and disintegrated tissue (*the pepsine* ?) to act in the liquefaction of food.

II. "Contributions to the History of Explosive Agents." By F. A. Abel, F.R.S., For. Sec. C. S. Received March 9, 1868.

(Abstract.)

The degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of such change, are, in the greater number of instances, susceptible of several modifications by variation of the circumstances under which the conditions essential to chemical change are fulfilled.

Excellent illustrations of the modes by which such modifications may be brought about are furnished by gun-cotton, which may be made to burn very slowly, almost without flame, to inflame with great rapidity, but without development of great explosive force, or to exercise a violent destructive action, according as the mode of applying heat, the circumstances attending such application of heat, and the mechanical condition of the explosive agent, are modified*. The character of explosion and the mechanical force developed, within given periods, by the metamorphosis of explosive mixtures such as gunpowder, is similarly subject to modifications; and even the most violent explosive compounds known (the mercuric and silver fulminates, and the chloride and iodide of nitrogen) behave in very different ways, under the operation of heat or other disturbing influences, according to the circumstances which attend the metamorphosis of the explosive agent (*e.g.* the position of the source of heat with reference to the mass of the substance to be exploded, or the extent of initial resistance opposed to the escape of the products of explosion).

Some new and striking illustrations have been obtained of the susceptibility to modification in explosive action possessed by these substances.

The product of the action of nitric acid upon glycerine, known as nitroglycerine or glonoine, which bears some resemblance to chloride of nitrogen in its power of sudden explosion, requires the fulfilment of special conditions for the development of its explosive force. Its explosion by the simple application of heat can only be accomplished if the source of heat be applied, for a protracted period, in such a way that chemical decomposition is established in some portion of the mass, and is favoured by the continued application of heat to that part. Under these circumstances, the chemical change proceeds with very rapidly accelerating violence, and the sudden transformation, into gaseous products, of the heated portion eventually results, a transformation which is instantly communicated

* Proceedings of the Royal Society, vol. xiii. pp. 205 *et seq.*