A FATAL FORM OF SEPTICÆMIA IN THE RABBIT, PRODUCED BY THE SUBCUTANEOUS INJECTION OF HUMAN SALIVA.

AN EXPERIMENTAL RESEARCH.

By Geo. M. Sternberg, *Surgeon U. S. A.*

In a report made to the National Board of Health in February last, I have given a detailed account of certain experiments, made in the first instance as a check upon experiments relating to the so-called *Bacillus maliariæ* of Klebs and Tommasi-Crudeli, which show that my own saliva has remarkable virulent properties when injected into the subcutaneous connective tissue of a rabbit. Further experiments made in the biological laboratory of the Johns Hopkins University have fully confirmed the results heretofore obtained, and the object of the present report is to place upon record these last experiments, which are of special interest just now because of the announcement by Pasteur of "*a new disease*," produced in rabbits by the subcutaneous injection of the saliva of an infant which died of hydrophobia in one of the hospitals of Paris. (Comptes Rendus Ac. d. sc. 1881, xcii, page 159.)

I have demonstrated by repeated experiments that my saliva in doses of 1.25 c. c.^{3} to 1.75 c. c^3. (see note 1) injected into the subcutaneous connective tissue of a rabbit, infallibly produces death within forty-eight hours.

I have commonly injected an amount varying from 5 to 25 minims, according to the size of the animal, but in small rabbits have had a fatal result in three cases out of five follow the injection of 1 minim diluted with 5 minims of water.

Query. Do similar results follow the injection of other fluids containing organic matter in suspension or solution?

Answer. One c. c^3. of my own blood failed to kill a rabbit; 1 c. c^3. of putrid urine containing *B. termo* in abundance failed to kill a small rabbit; 1 c. c^3. (each) of liquid fœces and distilled water (1 to 10) failed to kill two rabbits; 1.25 c. c^3. of bouillon undergoing putrefaction and loaded with *B. termo* failed to kill a rabbit; 1 c. c^3. of sediment from Baltimore water, consisting of organic *debris* and organisms—chiefly *Bacillus subtilis Leptothrix pusilla, Protococcus,* and a few diatoms and flagellate monads—failed (note 1) to kill a rabbit.

On the other hand, injections of a small quantity of surface mud from the gutters of New Orleans during the month of September, 1880, invariably produced fatal results within forty-eight hours. (See unpublished report above referred to.)

Note 1.—Coze and Feltz found as the result of numerous experiments that the blood of healthy persons and that of sick with non-infectious maladies does not produce fatal results when injected into the subcutaneous tissues of rabbits (Clinical and Exp. Researches upon Infectious Maladies. 8°, Paris. 1872). Pasteur also has inoculated, without result, the saliva of asphyxiated rabbits and of men dead with common diseases (*l. c.*).

Query. Does the saliva of other individuals injected in the same manner produce similar results?

Answer. The saliva of four students, residents of Baltimore (in March), gave negative results; eleven rabbits injected with the saliva of six individuals in Philadelphia (in January) gave eight deaths and three negative results; but in the fatal cases a less degree of virulence was shown in six cases by a more prolonged period between the date of injection and the date of death. This was three days in one, four days in four, and seven days in one.

Query. Is there any recognizable peculiarity in the saliva which exhibits the greatest degree of virulence?

Answer. In the case of Dr. S., whose saliva shows an exceptional virulence, the teeth are sound, the secretions of the mouth normal in physical properties and reaction, and the general health good. There is perhaps an unusual flow of saliva, but no other noticeable peculiarity.

Query. Is there any plausible hypothesis by which the difference in virulence can be explained?

Answer. This question will require for its solution more extended experiments. In the meantime it may be mentioned, as having a possible bearing upon the subject, that Dr. S. has been engaged to a considerable extent, during the past two years, in studies which have brought him in contact with septic material. Dr. F., of Philadelphia, whose saliva killed (after a long interval) two rabbits, is pathologist to a large hospital, and consequently is constantly brought in contact with septic material. Mr. N. and Mr. B., whose saliva killed all the rabbits operated upon (four), are residents of seaport towns in Cuba. (See Note 2.)

Note 2.—The possibility that this septic condition of the secretions of the mouth may bear some relation to the protection which these Cubans and myself enjoy against yellow fever, which is a disease presenting many points of resemblance to septicæmia, has occurred to me, and without at present laying any great stress upon this possibility, I think it worthy of further experimental consideration.

Query. Is death produced in other animals by the subcutaneous injection of human saliva which is virulent for rabbits?

Answer. Injection of 4^{cc} into each of two small dogs produced local abscesses at point of injection, but no other noticeable result. (See Note 3.) Injection of 0.25 to ^{cc} into five chickens produced no result. Injection of 0.75^{cc} (each) into three guinea-pigs proved fatal to two, one in three and one in seven days. Injection of 0.5^{cc} into five rats resulted fatally to one only. (See Note 4.)

NOTE 3.—A dog succumbed, however, to an injection of 1^{cm3} of serum from the subcutaneous cellular tissue of a rabbit recently dead.

NOTE 4.—The results obtained by me in these experiments correspond with those reported by Pasteur in the paper already referred to, viz. guinea-pig less susceptible than rabbit, complete immunity of the chickens, and susceptibility of the dog to the "new disease," as the result of injections of blood from dead rabbits.

Query. What is the nature of the fatal malady produced in rabbits by the subcutaneous injection of the saliva of certain individuals?

Answer. The course of the disease and the post-mortem appearance indicate that it is a form of *septicæmia*. Immediately after the injection there is a rise of temperature, which in a few hours may reach 2° to 3° centigrade (3.6° to 5.4° Fahrenheit); the temperature subsequently falls, and shortly before death is often several degrees below the normal. There is loss of appetite and marked debility after twenty-four hours, and the animal commonly dies during the second night or early in the morning of the second day after the injection. Death results still more quickly when the blood, &c., from a rabbit recently dead is injected. Not unfrequently convulsions immediately precede death. The date and mode of death correspond with that reported by Pasteur in the memoir referred to. Two rabbits injected with buccalmucus from the mouth of a child recently dead with hydrophobia, December 11, were found dead December 13. Other rabbits inoculated with the blood and saliva of these died in still less time. Inoculation with fresh blood usually produced death in less than twenty-four hours. The most marked pathological appearance is a diffuse inflammatory œdema or cellulitis extending in all directions from the point of injection, but especially to the dependent portions of the body.

Occasionally there is a little pus near the puncture, but usually death occurs before the cellulitis reaches the point of producing pus. The subcutaneous connective tissue contains a quantity of bloody serum, which possesses virulent properties, and which contains a multitude of micrococci. There is usually more or less inflammatory adhesion of the integument to the subjacent tissues. The liver is sometimes dark-colored and gorged with blood, but more frequently is of a lighter color than normal and contains much fat. The spleen is either normal in appearance or enlarged and dark-colored. Changes in this organ are more marked in those cases which are of the longest duration.

In certain cases dark-colored pigment has been found in the spleen resembling that which has been supposed to be characteristic of malarial fever. The blood is dark-colored, usually fluid, and there is a tendency to agglutination of the red corpuscles. The blood commonly contains an immense number of micrococci, usually joined in pairs and having a diameter of about 0.5 W. These are found in blood drawn from superficial veins, from arteries, and from cavities of the heart immediately after death, and in a few cases their presence has been verified during life; observations thus far made indicate, however, that it is only during the last hours of life that these parasites multiply in the circulating fluid, and in a certain proportion of the cases a careful search has failed to reveal their presence in post-mortem examinations made immediately upon the death of the animal. This organism, however, is invariably found in great abundance in the serum which exudes in considerable quantities from the œdematous connective tissue when an incision is made through the integument over any point involved in the inflammatory œdema extending from the original puncture. A perusal of the paper of Pasteur, already referred to, has induced me to pay special attention in three recent post-mortems to some points to which this author refers, which I had not noticed in previous examinations, viz, to the condition of the trachea, the lungs, and the lymphatic glands in the groins and axillæ.

Pasteur says: "The cellular tissue is almost always emphysematous. (This has not been observed to be the case, except to a slight extent in one instance, in the rabbits operated upon by me.) The lungs are frequently filled with *noyaux* of pulmonary apoplexy. (I have found this to be case in one out of three rabbits examined since my attention has been directed to this point.) 'A character more constant than the last (not more constant, however, than that which relates to the volume and color of the *ganglions*) is the state of the trachea, which is almost invariably red, congested, with little hemorrhages from the smallest vessels.'" (I have found a marked congestion of the vessels of the trachea, in the three cases in which I have examined it, and in one case the lymphatic glands of the axillæ were enlarged and congested.)

Query. What constituent of the saliva injected produces the fatal malady in question?

Answer. The following facts demonstrate that *the phenomena detailed result from the*

presence of a living organism found in the saliva—a micrococcus—which multiplies abundantly in the subcutaneous connective tissue, and also in the blood shortly before or after death.

(*a.*) *The poison is particulate.* This is proved by numerous filtration experiments. *Example:* March 15, 11 a. m., injected 1 ^{cc} of filtered saliva (filtered through thin stratum of plaster of Paris by means of Sprengel's pump) into left flank of rabbit weighing one pound, and at the same time one-fourth the quantity of unfiltered saliva into a rabbit of the same size. No harm resulted to the first rabbit, while the second died the following day at 5.30 p. m.

(*b.*) *The virulence of the saliva is destroyed by boiling.*

(*c.*) *The saliva loses its virulence when kept for twenty-four hours in a culture chamber at a temperature of* 37° *centigrade.*

NOTE.—The presence of *B. termo* and an odor of putrefactive in saliva kept for twenty-four hours in a culture chamber shows that changes are occurring which have heretofore been recognized as destructive of the septic poison (organism); *e. g.*, the virulence of the poison which produces dangerous dissection wounds is lost when putrefaction changes set in.

(*d.*) *The addition of one part of a* 10 *per cent. solution of carbolic acid to two parts of saliva destroys its virulence.*

(*e.*) *The effused serum from the subcutaneous connective tissue of a rabbit recently dead produces death, attended with the same phenomena as resulted from the injection of the saliva in the first instance.* But this does not contain epithelial cells or salivary corpuscles, and we are, therefore, justified in excluding these as possible agents in the production of the results indicated. Moreover, these are present at all times in the saliva of all individuals, while virulence, at least such an intense degree of virulence, is an exceptional property of human saliva.

(*f.*) *This serum loses its virulence by filtration.*

Unfiltered serum from a recently dead rabbit has invariably proved fatal in smaller quantity and in less time than is required by the saliva in the first instance, showing an increase of virulence as the result of successive cultivation of the organism in the body of a susceptible animal. This corresponds with the results obtained by Davaine, Koch, Pasteur, and others. I have not attempted to ascertain the minimum quantity which will produce death. Davaine says, "A rabbit may be killed by the $\frac{1}{1000}$ part of a drop of septic blood." (Bull. de l'Acad. de Med., 2 s. t. viii, p. 121.) In my filtration experiments I injected, however, quantities far in excess of the amount required to produce speedy death if unfiltered serum had been employed.

Example: March 14. Injected 2 cm^3 of filtered serum (from subcutaneous connective tissue of rabbit recently dead) diluted with distilled water (1 to 20) without result, while one-quarter of the quantity (5 cm^3) of the same dilution *unfiltered* injected at the same time into another rabbit produced death in twenty-four hours.

(*g.*) The micrococcus present in the serum from the connective tissue of a rabbit which has succumbed to a subcutaneous injection of saliva may be cultivated in bouillon made from the flesh of a healthy rabbit, or in blood serum obtained from a healthy dog, and these fluids thereby acquire a virulence which they did not have before.

My first efforts to cultivate the micrococcus in urine, in gelatine solution, and in bouillon made from the flesh of a dog, all proved ineffectual, and these fluids, after inoculation with blood or serum from the connective tissue, showed a temporary virulence only, which was doubtless due to the presence of the micrococci introduced, which preserved their vitality for a certain time, although the conditions were not favorable for their increase. After a few days the first culture lost its virulence, and successive inoculations gave negative results, both as to the presence of the micrococcus and as to noxious properties when injected into rabbits.

(*h.*) Successive cultures in which but a small drop is taken each time to inoculate a fresh quantity of bouillon exclude the white and red blood-corpuscles (filtration experiments have already shown the poison to be particulate) as possible agents in the production of this virulence and prove conclusively that the veritable cause is the presence of a micrococcus, found first in the saliva, then in the serum from the connective tissue and (usually) in the blood of the animal killed by the injection of saliva, and finally in each successive culture fluid inoculated (in the first instance) with a small quantity of this serum or blood. Within a few hours after inoculating sterilized bouillon made from the flesh of a rabbit (first tested for several days in a culture oven at a temperature of 37° cent.), with blood, or serum from subcutaneous connective tissue of a rabbit recently dead, the fluid—previously transparent—becomes opalescent, and upon microscopical examination is found to contain innumerable micrococci, solitary, in pairs, (Fig. 8), and in torula chains. The same result follows upon inoculating a second portion with a minute drop from the first, and so on. The continued virulence of these successive cultures I have amply proved.

Example: April 13. Injected 1 cm^3 of bouillon culture No. 6 (six successive inoculations, the first with serum from subcutaneous connective tissue of rabbit) into left flank of a large rabbit. *Result:* The animal was found dead on the morning of

the 16th, and presented the usual appearances upon post-mortem examination. Its blood and the effused serum in subcutaneous connective tissue contained, as usual, an immense number of micrococci, like those already described.

Query: Does the micrococcus found under the circumstances detailed differ from the *Micrococcus septicus* of Cohn, and is it identical with the organism described by Pasteur, as present in the blood of rabbits killed by the subcutaneous injection of the saliva of an infant dead from hydrophobia (1. c.)?

Answer. Cohn describes the *M. septicus* as follows:

Little rounded cells of 0.5 μ motionless and crowded in masses or united in chaplets in the secretion of wounds in cases of septicæmia (Klebs), in *zooglœa*, in callous ulcers, in isolated cells, united *in pairs*, or in chaplets in the serum of *epidemic puerperal fever* (Waldyer) in all the tissues, vessels, &c., in cases of pyæmia and septicæmia. (The Bacteria; Magnin, Little, Brown & Co. Boston, 1880, p. 76.)

Pasteur gives the following description of the micrococcus found by him in the fatal disease described by him as new, and which he evidently does not consider identical with septicæmia, a disease which he had previously studied experimentally. It should be noticed, however, that Pasteur recognizes several forms of septicæmia. Thus he says: "And now we see why septicæmia has so often been confounded with charbon; their causes are of the same order; it is a vibrio which causes septicæmia and a bacillus which produces charbon. * * * Septicæmia and putrefaction in a living being are not the same thing. *There are as many different septicæmias as there are different vibrios.* * * * In septicæmia the vibrios do not appear in the blood until the last thing, but in this liquid one of them takes a peculiar aspect, often longer than the diameter of the field of the microscope, and so transparent that it easily escapes observation; when, however, it is once perceived it is easily found again, flexible, climbing and removing the blood-globules as a serpent moves the grass in the bushes, etc. (Charbon and septicæmia. C. R. Ac. des Sc., lxxxv, 101–115.)

This septic vibrio of Pasteur I found in the blood of rabbits, victims of my experiments, in New Orleans during the past summer, but have not since met with it; perhaps, because it develops *post mortem*, and requires the hot weather of summer for its development. Whether it is an independent organism or is developed under special conditions from the *Micrococcus septicus*, being an advanced phase in the development of this organism corresponding with the spore-producing filaments which have been shown to constitute one phase in the life history of *Bacillus anthracis* (Koch) and of *Bacterium termo* (Ewart) is an interesting question for further research. The vivid language of Pasteur describes it well, and the wonderful vigor with which this extremely slender and almost transparent organism thrusts aside the blood corpuscles in its impetuous serpentine movements cannot fail to astonish the observer.

The micrococcus of Pasteur's "new disease" is, on the contrary, quite motionless, and is described as follows:

This organism is sometimes so small that it may escape a superficial observation. Its form does not differ from that of many other microscopic beings. It is an extremely short rod a little compressed towards the middle, resembling a figure 8, and of which the diameter of each half often does not exceed a half a thousandth of a millimeter [= 0.5M and corresponding with the diameter given by Cohn for the *Micrococcus septicus*, also with the micrococcus observed by myself in the form of septicæmia described in this report]. Each of these little particles is surrounded at a certain focus with a sort of aureole, which corresponds perhaps to a material substance.

(NOTE.—The possibility that this appearance is due to diffraction is considered, but Pasteur inclines to the opinion that in the case in question it is due to a mucous substance which surrounds the organism.)

The foregoing descriptions answer as well for the micrococcus observed by me as if they had been written especially for it, and it is unnecessary for me to say more at present in relation to the morphology of this organism which apparently is identical with that of the *Micrococcus septicus* of Cohn, and with the organism found by Pasteur in the "new disease" described by him. Does it, then, follow that the organisms are identical, and that the phenomena related by Pasteur as resulting from the subcutaneous injection of saliva from an infant dead of hydrophobia and by myself from the saliva of a healthy adult represent the same disease? By no means. The man of science soon finds that things which look alike are not necessarily of the same kind. Thus, of two transparent colorless fluids, one may be harmless water and the other a corrosive acid; two embryos apparently alike may develop, the one into a man and the other into a monkey; two seeds of the same size and general appearance may produce, the one a cabbage, the other a turnip, &c. The argument, then, that because a certain bacillus, or spirillum, or micrococcus, is morphologically identical with another which is proved to be harmless as to its effects upon an animal organism, consequently *it* must be harmless, has no support from analogy, any more than it has from experiment. And it is high time that naturalists and physicians should open their eyes to the fallacy of such an argument, as it not only has a ten-

dency to close the minds of those who receive it to the reception of demonstrated truths, but also acts to some extent as a bar to the progress of science in this direction.

The argument is: Bacteria are found everywhere. We eat them, we drink them, we draw their germs into our lungs at each inspiration and without apparent injury. They are evidently harmless. Your spirillum of relapsing fever does not differ (the morphological resemblance is admitted) from a harmless spirillum frequently found in the human mouth; your *Bacillus anthracis* does not differ from *Bacillus subtilis*, &c. The answer is plain. The fact that there are harmless bacteria does not disprove the possibility of pathogenic bacteria; the fact that two things look alike does not prove that they are alike; experiment proves conclusively that the phenomena of anthrax are due to the presence and multiplication in the body of affected animal of the *Bacillus anthracis*, and that in the fatal form of septicæmia described in this report the efficient cause of the morbid phenomena and of death is the minute micrococcus described. Doubtless, harmless micrococci abound. Pasteur finds no difference, morphologically, between the organism which produces the "new disease" described by him and that which produces the *cholera des poules*. He says: "By the form which it has in the blood the organism resembles the microbe of chicken cholera, but it differs completely in its functions. We may inoculate fowls with it without their experiencing the slightest ill effect. (The same is true of the organism producing the form of septicæmia described in this paper.) In the form of chaplets it resembles greatly many other organisms which I have often observed, &c.

It will have been noticed from the account already given that the fatal disease in rabbits observed by me, and resulting from the subcutaneous injection of my own saliva, resembles in many particulars the disease described by Pasteur as new, resulting from the subcutaneous injection of the saliva of a child dead with hydrophobia. Another point of resemblance is the fact that the saliva of one of my rabbits recently dead has the same virulence as the blood and serum from connective tissue. A serous liquid, which in some instances escapes from the bowels shortly before or after death, also contains the micrococcus in abundance and possesses like virulence. All of these points of resemblance form a strong probability in favor of the identity of the two diseases, but I am not prepared to pronounce a positive opinion upon this point, especially since Pasteur, who had previously given much attention to the study of septicæmia, pronounces the disease observed by him to be new. While I see no reason at present for supposing that the disease observed by me differs essentially from the experimental septicæmia produced by Davaine, Koch, and other investigators who, however, obtained their first supply of septic organisms from a different source.

In the light of what we already know, it seems very probable that purperal fever, hospital gangrene, and the various forms of septicæmia known to physicians and surgeons result from the development of pathogenic varieties of harmless and widely-distributed species of micrococci, as the result of especially favorable surroundings, such as are found in the lochial discharges of a puerperal woman or in the secretions from the surface of wounds in a crowded and illy-ventilated hospital ward.

Just as differences in resisting power to experimental septicæmia are exhibited by different species of animals, so doubtless individual differences exist in man, especially as the result of lowered vitality; and this want of resisting power, from whatever cause resulting, must be counted as one of the conditions favorable to the development and propagation of a pathogenic bacterium. Thus we find that in experimental septicæmia the micrococcus does not invade the blood until the vital powers are at a low ebb and death is near at hand.*

In the dog the vital resistence is competent to withstand the assaults of a micrococcus—injected subcutaneously—having the potency of those found in my saliva, and the result of such an injection is simply a circumscribed abcesss. But the increased power (which is perhaps simply a more vigorous and rapid development) gained by cultivation in the body of the rabbit and a diffuse cellulitis results of fatal character.

The fact observed by myself that during the summer months the mud in the gutters of New Orleans possesses an extraordinary degree of virulence† shows that pathogenic varieties of bacteria are not alone bred in the bodies of living animals. The more I study this subject the more probable it seems to me that in this direction lies the explanation of many problems which have puzzled epidemiologists and that the sanitarians are right in fighting against filth as a prime factor in the production of epidemics—a factor of which the *rôle* is easily understood, if this view is correct. The presence of septic organisms possessing different degrees of virulence depending

*By virtue of some property or mechanism at present unknown, blood, which, external to the body, is a favorable medium for the development of many species of bacteria, resists their entrance or gets rid of them when they effect an entrance, *e. g.*, by injection, so long as it is circulating in the vessels of a healthy individual.

†There is no reason to suppose that this is peculiar to New Orleans, but I have not yet had an opportunity to extend my experiments to other places.

upon the abundance and kind of pabulum furnished them and upon meteorological conditions more or less favorable constitutes, in my opinion, the *epidemic constitution of the atmosphere*, which wise men were wont to speak of not many years ago as a cloak for ignorance. It must be remembered that the gutter mud of to-day, with its deadly septic organisms is the dust of to-morrow, which in respiration is deposited upon the mucus membrane of the respiratory passages of those who breathe the air loaded with it.

Whether the peculiar poison of each specific disease is of the same nature or not—a question which can only be settled by extended experimental investigations in the future—it is altogether probable that this factor often gives a malignant character to epidemics of diseases which uncomplicated are of a comparatively trivial nature.

APPENDIX 3.

CARBONIC OXIDE AS A SOURCE OF DANGER TO HEALTH IN APARTMENTS HEATED BY CAST-IRON FURNACES OR STOVES.

By IRA REMSEN, Professor of Chemistry in the John S. Hopkins University.

In 1865 a peculiar epidemic occurred in Savoy. It was a new thing, and consequently new theories were put forward to explain it. Among these, the one which attracted most attention was that of M. Carret, who, in a communication* read before the French Academy, attempted to show that the disease was due to the use of cast-iron stoves, from which in some way carbonic oxide was given off, thus contaminating the air.

General Morin then became interested in the subject and requested† Messrs. H. Sainte-Claire Deville and Troost to make a chemical examination of the air in immediate contact with a specially constructed cast-iron stove heated to redness, as he thought that Carret's statement might possibly be explained by supposing that carbonic oxide passes through the red-hot iron, as earlier experiments of Deville and Troost had shown that this is possible. The work undertaken by the last-named chemists led them to the belief that carbonic oxide may and does pass through cast iron heated to redness. As their experiments were the first undertaken to determine whether cast-iron stoves are objectionable or not, and as the names of the chemists have carried great weight in the discussion of the question, it is desirable to know here exactly what they did:‡

They first analyzed the air of a room heated by a cast-iron stove, and found considerable quantities of carbonic oxide and of hydrogen. They then took the apparatus furnished by General Morin, consisting of a specially constructed cylindrical cast-iron stove, surrounded by an envelop of cast iron fitting into grooves in plates above and below the stove. The air was drawn out of the space between the stove and the envelope, and then passed over pumice-stone moistened with sulphuric acid and over caustic potassa. Thus freed from water and carbonic acid, it was passed into a combustion tube containing heated cupric oxide, the water and carbonic acid thus obtained weighed, and the weights of hydrogen and carbonic oxide deduced from those of the water and carbonic acid. The amounts found vary between 0.250 and 1.072 parts hydrogen, and between 0.141 and 1.32 parts carbonic oxide in 1,000 parts of air. These experiments have been justly criticised by others, and I only record the judgment of every thinking chemist when I say that the experiments do not furnish satisfactory proof of the presence of carbonic oxide in the air. In the first place there is always present in the air a certain amount of organic matter of complex nature which by combustion will yield carbonic acid and water; and hydrocarbons, which are, as is well known, formed in large quantity by the heating of coal, might also be present in the space immediately surrounding the stove. These would also yield carbonic acid and water by combustion.

A little later the French Academy, impressed with the importance of the subject, appointed a committee, consisting of MM. Payen, Morin, Fremy, H. Sainte-Claire Deville, Boussy, and Claude Bernard, to make a thorough investigation. The committee began working March, 1868, and continued until February, 1869, when General Morin, at the request and in the name of the other members, handed in an exhaustive report to the academy.§

*Comptes rendus 66, p. 792.
†Comptes rendus 66, p. 82.
‡Comptes rendus, 66, p. 83.
§Comptes rendus 68, p. 1006.