AN INVESTIGATION INTO THE SO-CALLED HENDON COW DISEASE, AND ITS

RELATION TO SCARLET FEVER IN MAN.

Abstract of a Report to the Agricultural Department of the Privy Council, read before a Special Meeting of the Pathological Society of London, Thursday, Dec. 15, 1887.

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Origin of the Investigation.—*Scarlatina in Marylebone.*—*Mr. Power's Diagnosis.*—*Dr. Cameron's Account.*—*The Disease in Man.*—*Symptoms in the Cow.*—*Character of the Eruption.*—*Dr. Cameron's Diagnosis from Cow-pox.*—*Dr. Klein's Account.*—*Post-Mortem Appearances.*—*Inoculation Experiments.*—*The Micrococcus of Scarlatina.*—*Inoculation with Cultivations.*—*Dr. Klein's Conclusion.*—*An Eruptive Disease is Reported.*—*Character of the Eruption.*—*Examination for Micro-organisms.*—*Inoculation Experiments.*—*Cultivation Experiments.*—*Another Outbreak.*—*Natural Infection.*—*Inspection of an Infected Herd.*—*The Disease in Man.*—*Absence of Scarlatina among the Consumers of the Milk.*—*Nature of the Disease.*—*Diagnosis from Spurious Cow-pox.*—*General Remarks.*—*Conclusions.*

Though the investigation which I bring before you to-night is not yet complete in many details, I feel that, as the subject is of such great public importance, and information is awaited with keen anxiety in the agricultural world, it is right that an account of what has so far been done should at once be published, especially as the evidence which has already come to hand has forced me to come to definite conclusions. I would add, I feel strongly in investigations which are so strictly pathological, that the assembly to whom the results should first be made known is this Society. I desire, therefore, most cordially to express my indebtedness to Professor Brown, of the Agricultural Department of the Privy Council, for giving me permission to lay this matter before you, and to you, Sir, for having enabled me to do so without any delay.

Origin of the Investigation.—I will ask you first of all, Sir, to allow me to remind you of the circumstances which have led to a searching inquiry being instituted by the Agricultural Department of the Privy Council into a disease in cows and its relation to scarlatina in man.

Scarlatina in Marylebone.—On December 18th, 1885, Mr. Winter Blyth reported to the Local Government Board a sudden and extensive outbreak of scarlatina, which was associated with the distribution of milk by a particular retailer in South Marylebone. The retailer procured his milk from two farms, and there can be little doubt that the milk responsible for the outbreak was derived from a certain dairy farm in Hendon. Mr. Blyth and the medical officer of health for Hendon, Dr. Cameron, were unable to obtain any clue as to the source of infection, and Mr. Power was deputed by the Local Government Board to make an inquiry into the matter.

Mr. Power's Diagnosis.—Mr. Power, having come to the conclusion that the milk had not become infected from any human source, proceeded to investigate the condition of the cows. A careful examination was made, with a view to detecting any disease among the cows, and it was discovered that there were several on the farm which were suffering from a disease characterised by the appearance of vesicles and ulcers on the teats and udders. At this stage Dr. Klein became associated with Mr. Power in the inquiry, and we are told that their belief in the existence of a constitutional disease among the cows on the farm, capable of producing scarlatina among human consumers of the cows' milk, became unreserved. Dr. Klein took with him samples of milk, contents of vesicles, and discharges from ulcers, and afterwards two cows were purchased and conveyed to the Brown Institution. At this stage of the inquiry a cowman pointed out to Dr. Klein that he had seen the disease on a certain cow, which was one of a batch that had been imported on November 15th from Derbyshire.

Dr. Cameron's Account.—In a paper read before the Epidemiological Society, Dr. Cameron gave a detailed description of this cow disease. He pointed out that it was a specific contagious and infectious disease, capable of being communicated to healthy cows by direct inoculation of

the teats with virus conveyed by the milker from a diseased animal. Further, he pointed out that the disease was communicable to man.

The Disease in Man.—A trusty informant received the virus into a recent scratch on the forefinger while milking a diseased cow. General weakness, *malaise*, and loss of appetite resulted, and after about four or five days a vesicle or small blister appeared on the finger. This broke, and several others formed on the back of the hand. The whole hand and fingers became swollen and inflamed, the inflammation extending in broad lines as far as the elbow. The general disturbance lasted a fortnight.

Symptoms in the Cow.—Dr. Cameron regarded the disease in the cow as constitutional, and he pointed out the occurrence of initiatory fever, cough, sore-throat in severe cases, discharges from the nostrils and eyes, eruption on the skin round the eyes and on the hind quarters, vesicles on the teats and udders, and visceral lesions.

Character of the Eruption.—The condition of the teats is described as follows: The teats became enlarged, swollen to nearly twice their natural size, and oedematous. On fingering them there was no feeling of induration. Vesicles or bullæ then appeared on the swollen teats and upon the udder between or near the teats. These varied in number from two to four on a teat and in size from a pea to a horse-bean. The vesicle contained a clear fluid. The vesicle, Dr. Cameron adds, was not preceded by a hardened papule, but was in the first instance a vesicle or bulla. The vesicles were rubbed and broken on milking and left raw sores, sometimes red, in other cases pale in colour with raised ulcerated edges. Sometimes a few accessory vesicles formed around the margin of these ulcerated sores. After the rupture of the vesicle a brown scab formed, which might remain attached for five or six weeks or fall off in ten days or a fortnight, a smaller one forming afterwards. A thin watery fluid exuded from under the scab, and the sore ultimately healed. Many scabs varied in size from a shilling to a florin; they were about one-eighth of an inch thick in the centre, thinning off towards the edges. When picked off the recently-healed skin was of a pearly-blue colour, with slight tendency to bleed when the scabs were forcibly detached. According to Dr. Cameron, there was no depression of the vesicle or pitting of the skin. The swelling of the teat gradually subsided.

Dr. Cameron's Diagnosis from Cow-Pox.—Dr. Cameron thus sums up the diagnosis from cow-pox: No hard pimple preceding vesiculation, no subsequent formation of pustule, no central depression of the vesicle, no marginal induration, no areolæ, and no pitting. In connection with this it should be observed that Dr. Cameron acknowledges that not all of his account had been the result of personal observation, and that of necessity some of the earlier symptoms had been learnt from other persons.

Dr. Klein's Account.—I will now follow with the account given by Dr. Klein. He states that on the teats and udders of two cows which he investigated, there were several flat irregular ulcers, varying in diameter from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch. Some ulcers were more or less circular, others extended in a longitudinal direction on the teat. The ulcers were covered with a brownish or reddish-brown scab. The margin of the ulcer was not raised, nor was there any perceptible redness of the skin around. A small vesicle would make its appearance on a greatly swollen teat, and in the course of a couple of days, assume the character of the above ulcers. As a rule the disease affected the teats, but in some there was also, on the lower part of the udder here and there, an ulcer. In such animals, patches denuded of hair were noticed on various parts of the skin, the tail and back particularly. In these patches the epidermis was scaly, and the cutis more or less thickened. The animals looked thin, but not strikingly so. In feeding capacity, milking power, and body temperature, there was nothing abnormal. Two of these animals, as I have already mentioned, were sent to the Brown Institution.

Post-Mortem Appearances.—Both were killed, and at the necropsy there were found on one (No. 3) petechiæ under the pulmonary pleura, peripheral lobules congested, adhesions between lower lobes of lung and costal pleura. In the liver reddish streaks and patches, spleen and kidneys slightly congested, on the placenta petechiæ. In the other (No. 4) there were numerous congested lobules in the lungs, and pleural adhesions, cortex of kidneys congested.

Inoculation Experiments.—To study the transmissibility of the disease, Dr. Klein inoculated four calves in the corium of the groin, and the inside of the ear, with scrapings from the ulcers after removal of the crusts. In calf No. 3 there was a vesiculation at the margin of the spot inoculated, and in the centre commencing formation of a crust. On the seventh day each sore on the ear had enlarged to about half an inch in breadth, and was covered in its whole extent by a brownish crust. On the eighteenth day they had all healed up, and become converted into flat scars.

The Micrococcus of Scarlatina.—To search for micro-organisms, Dr. Klein removed the crust from an ulcer on the teat, scraped off the most superficial layer, squeezed the ulcer, and made cover-glass preparations with the exuded lymph. Tubes of nutrient gelatine and nutrient agar-agar were also inoculated. Dr. Klein succeeded in isolating a micrococcus which, after three to six days at 20° C., formed at the line of inoculation small points or granules, whitish in colour, and tolerably closely placed. In the depth of gelatine the channel of inoculation was visible as a whitish streak, made up of smaller and larger droplets. The gelatine was not liquefied. Cultivated in milk and incubated for two days at 35° C., the milk was turned solid. Microscopic examination of a culture showed that there were micrococci, diplococci, and shorter and longer chains. In both, after two or more weeks' incubation, very long chains were formed. The micrococci showed a peculiar mode of division. The chains showed branchings, and here and there in a chain the presence of a large element amongst the smaller ones.

Inoculation with Cultivations.—Dr. Klein inoculated two calves in the groin with the cultivated micro-organism. One calf died in twenty-seven days. No ulcers resulted, as after inoculation with the scraping of the sores; but at the necropsy there were found peritonitis, hæmorrhagic spots on omentum, congested liver, kidneys, and lungs, petechiæ under the pleura, and pericarditis. In the second calf, on the nostrils and lips, and in the hard palate and gums, numerous irregularly outlined patches were seen. They were discoloured, brownish, with a very slightly raised margin, and a paler centre. This animal was killed, and at the necropsy there were congested lungs, kidneys, and hæmorrhagic patches on the spleen. Thus in neither of these cases was a real ulcer produced as the result of the inoculation of the cultivated organism, but the *post-mortem* appearances and anatomical features recalled to Dr. Klein the lesions of scarlatina. In the kidney, for example, there were congestion of the cortex, hæmorrhages and glomerulo-nephritis, and granular or opaque swelling of the epithelial cells and infiltration with round cells. From the blood of the heart, the micrococcus which had been used in the inoculation was recovered. In view of this evidence, Dr. Klein concluded that the streptococcus was identical with the virus of the cow disease, and that it produced a disease very closely resembling that of scarlatina. In a paper read before the Royal Society, Dr. Klein describes how the work was carried on during 1886-1887. Dr. Klein found in the blood of human scarlatina that a micrococcus was present in four out of eleven cases. The micrococcus proved to be identical in its microscopical appearances and its characters on cultivation with the micrococcus found in the Hendon cow disease. And by inoculation with a cultivation of the scarlatina micrococcus, he states that a cutaneous and vesical disease resulted, which was identical with that produced in the calves infected with the micrococcus from the Hendon cows.

Dr. Klein's Conclusion.—In conclusion, Dr. Klein says, "it must be evident from these observations that the danger of scarlatinal infection from the disease in the cow is real, and that towards the study and careful supervision of this cow disease all effort ought to be directed to check the spread of scarlet fever in man."

An Eruptive Disease is Reported.—Cases of an eruptive disease of the cow having been reported to the Agricultural Department of the Privy Council, I received instructions from Professor Brown to undertake a series of researches on the lines indicated by Dr. Klein. The first animal that came under my observation had been purchased and removed to the Royal Veterinary College. This cow I shall speak of as No. 1. She was fairly well nourished, ate well, and was said to be normal in her milk supply. Her temperature was normal on admission, but subsequently rose, from mastitis occurring as a complication. There was no desquamation, nor were there in this case any patches destitute of hair.

Character of the Eruption.—But there was a characteristic disease of the udder and teats. On the right teats there were numerous sores, varying in size from a pea to a penny. The sores were covered with crusts varying in thickness and generally fissured; in some they were flat, in others conical; some were with difficulty removed with forceps, others were readily detached. The crusts varied in colour from reddish-brown to a very dark brown or almost black. On detaching or scraping a crust there was a granulating and somewhat indurated base. On the right anterior teat there were several ulcers, from which apparently the thick crusts had been detached, and new scabs were forming. On the left posterior teat there were unusually dark brown crusts, especially at the extremity of the teat.

Examination for Micro-organisms.—Having entirely removed the crusts from some of these ulcers, I squeezed the base, and from the discharge I made a number of inoculations in nutrient gelatine and

nutrient agar-agar. I also collected the discharge in capillary tubes and sealed them immediately, and also made a number of cover-glass preparations.

Inoculation Experiments.—With the discharge and with scraping from the ulcers I inoculated four white mice, one guinea-pig, and two calves. Of the two calves, one was inoculated by scarification in both ears; the other was scarified in the left ear and inoculated in the left groin by making an incision through the corium and rubbing in a scraping from an ulcer. In each ear and in the groin there were positive results. In the large brown calf inoculated in the right ear in two places, one place went through the following changes. On the third day there was apparent vesiculation, and commencing formation of crust. From day to day the crust thickened, and on the eighth day the crust was at its height, and detached at its edges. By removing the scab an ulcer was exposed; there was slight inflammatory thickening. About the thirteenth day the ulcer had quite healed. This corresponds very closely with the results obtained by Dr. Klein. The temperature of the calf was only slightly raised.

Cultivation Experiments.—I will now describe the result of the cultivations. The inoculations had been made for the most part in tubes of nutrient gelatine and nutrient agar-agar solidified obliquely. To separate the different organisms that might be present I employed either Koch's plate-cultivations or Esmarch's method, or I simply drew the platinum needle in a line on the surface of the nutrient medium. Agar-agar tubes, inoculated in this way, were placed in the incubator at 37° C., and gelatine tubes were kept at 20° C. In the course of two or three days a growth commenced along the track of the needle consisting mostly of china white, yellow, orange, and little dot-like colonies. Examination of the latter with a magnifying glass showing a little darkened centre corresponding exactly with the figure given by Dr. Klein. Cover-glass preparations revealed at once an organism identical in form with that described by Dr. Klein. From these colonies cultivations were established in a number of tubes of nutrient gelatine, and in two or three days at 20° C. the cultivations gave the peculiar finely-dotted appearance which has been figured and described so minutely. These preparations were demonstrated to Professor Brown on November 23rd. This micrococcus grows also in broth and turns milk solid, so that it exactly corresponds with the description and figures given by Dr. Klein of the so-called *micrococcus scarlatinae*. As I had procured cultivations, the animal was ready to be killed, and Professor Brown was anxious that Dr. Klein should be present at the *post-mortem* examination. In deference to Dr. Klein's wishes, the cow was conveyed to the Brown Institution on the condition that due notice was given to enable us to be present at the necropsy.

Another Outbreak.—On November 24th I accompanied Professor Brown to see another cow affected with a similar disease belonging to a herd in another county. The affection in this case was not so severe, but it also showed the same characteristic brown or reddish-brown crusts, which on removal exposed a granulating, thickened base, with exudation of a lymph-like discharge and slight hæmorrhage.

Natural Infection.—The cow was suckling a calf, and this calf had previously been suckled by another cow also affected with the same eruption of the udders and teats. The calf had developed flat, angry looking ulcers on the nose and hard palate, and an eruption in the hairy part of the nose near the muco-cutaneous line of union. Calf No. 1 having been sent to the Brown Institution, a second cow (No. 2) was purchased from the same herd as No. 1. This cow also had a calf with suspicious places on each nostril—on the right an apparent abrasion, and on the left side a distinct but thin flat brownish scab. It would appear then that these calves had inoculated themselves by sucking the sore teats.

Inspection of an Infected Herd.—On Saturday, November 26th, I proceeded to the affected farm from which the diseased cows Nos. 1 and 2 had been purchased. On my arrival I made inquiries as to the first occurrence of the outbreak. I gathered that it appeared about the end of September, but it was said that no fresh cows were imported at that time. The disease commenced at a farm which I shall call V. The cows were moved from farm to farm, so the disease spread through all the farms W, X, Y, Z. In all there were about 160 cows. By examining two milkers I obtained the following history. They said that the teats swelled, were hot to the touch, and very tender; as a result the animals were milked with difficulty. In milking they resorted to the standing position, as otherwise they and their milk-pails were upset. In some cases the pain on milking was so great that the animals became almost unmanageable, and had to be tied by the legs. One man described the pain caused in milking the severe cases as "most barbarous." They stated that a little white bladder would rise up on the teat, which would become as large as a

pea, or much larger, and then was burst in the milking. As a result a sore formed and became covered with a scab. Matter formed under the scab, and as the scabs were broken in milking, matter and blood would come out on their fingers and get mixed with the milk. Sometimes the scabs would become rubbed off, in other cases they fell off, and finally, in four or five weeks, the sores would be healed.

The Disease in Man.—At these farms I found that the disease had been communicated to several of the milkers. They had been inoculated some weeks before my visit, so I had at this stage no opportunity of seeing the early changes. I had, therefore, to rely a great deal on their description. I will select a few cases. Cowman R. showed me a scar on his right hand. He said he was the first to catch the disease. It came as a hard, painful spot, which formed matter and then a big scab. He had continued milking ever since, but had no fresh "places." Cowman F., about a month ago, noticed spots which appeared on both hands. His fingers swelled and were painful. He says it came first like a pimple, and felt hard. Then it "wept out water" in four or five days. There were red marks creeping up his arm. There was a sort of throbbing pain, and he could not sleep at night. When I saw him I found on the right hand a scar, but on the left hand there was an ulcer about the size of a shilling, covered with a thick black crust. The crust was partially detached, and exposed a granulating ulcer. It was the exact counterpart of an ulcer on a cow's teat. Cowboy H. had both hands bad about a month ago: first the index finger of the left hand, and then the right hand. He says that it came up like a hard pimple, and the finger became swollen and red. After a few days it "wept out water," and then matter came away. Both his arms were swollen, but his left arm was the worst. About a fortnight after he noticed "kernels" in his armpits, which were painful and kept him awake at night. His arms became worse, he could not raise them, and he had to give up milking. He also had a bad place on the lower lip. On examination I found that the axillary glands were still enlarged and tender. He volunteered the statement that the places were just like the sore teats. H., the bailiff's son, had a sore on the upper lid of the right eye, and on his left hand. In both places he had previously been scratched by a cat. The right hand had also been infected. It commenced, he says, a fortnight ago. His hands were swollen, red, and hot. He felt very poorly and went to bed. Little spots like white blisters appeared on the back of his right hand, these broke and "rose up" in thick scabs. He was very ill for two or three days, but did not send for a doctor. He had painful lumps at the bend of the arm and in the armpit. He gave up milking and had not taken to it since.

Absence of Scarletina among Consumers of the Milk.—As I have said, there were altogether about 160 animals on these farms, and all or nearly all had contracted the disease. The milk was drunk on the farms and in the village, but most of it, amounting to eight churns a day, that is, 64 barn gallons or 1,088 pints, was sent twice a day to a large city. Not being distributed in a wealthy neighbourhood, we may roughly estimate the number of persons drinking the milk at about 1,500 or 2,000. I was informed that there were no cases of scarlatina on the farms or in the village. In the town district in which the milk was distributed there was no epidemic. From these observations and researches, I think that we are justified in concluding that the disease I have described is identical with the Hendon cow disease. For: (a.) In both cases we have an eruption confined almost entirely to the teats, and presenting precisely the same appearance, and with the same history. (b.) In both the disease is communicated from animal to animal by the virus being conveyed by the hand of the milker. (c.) In both the disease is communicable to man when the virus is received into abrasions or scratches on the skin, and produces, judging from the description, a similar disease. (d.) In both the disease is communicable by experimental inoculation. (e.) In both there are occasionally the same constitutional symptoms: slight rise of temperature, eruption on the skin, patches devoid of hair, running from the eyes, etc. (f.) In both there are streptococci, associated with the disease which are identical in every respect in their microscopical appearances, and in their characters on cultivation in nutrient gelatine, nutrient agar-agar, in broth, and in milk. And therefore I am of opinion that we are justified in concluding that the Hendon cow disease was not scarlatina in the cow, and that in the Hendon milk the source of infection was from some hitherto unascertained human source.

Nature of the Disease.—I now pass on to give you my opinion as to the nature of this disease. The appearance of the eruption, especially in the bailiff's son, aroused a suspicion in my mind, and, on returning from my visit to the farm, I very earnestly questioned some leading veterinary surgeons as to the nature of the disease in the cow. I was assured that it was very common and very well known, though not

described in the textbooks of veterinary medicine. It was referred by them to various causes. In deference to their opinion I even suggested that, if it were an undescribed disease, it might appropriately be termed a contagious mammillitis. But my suspicions clung to me, and were strengthened by studying the descriptions of affections of the teats in the cattle, and I expressed to several my disappointment at not having had an opportunity of seeing the earlier stages of the disease in man. I therefore determined to visit the affected farm again and again, with a hope of seeing some fresh cases. On December 2nd I was rewarded for my trouble, for in course of conversation with a head cowman my attention was drawn to a lad who was standing at some little distance. I was told that this was a new case, and an examination of his face revealed to me in a moment that my suspicions were well founded, for I was convinced *this disease of the teats of the cattle was the true Jennerian cow-pox*. My first impulse was to carry the boy straight off to London, but the question of accommodation led me to have advice first as to what course I should pursue. I therefore made a drawing of the boy's face, filled a number of tubes with lymph, and then spent the rest of the day in visiting a farm I had not previously seen. Here I found a very intelligent head cowman whom I had not interviewed before, and I determined to elicit from him all he knew of this disease in his own words. He said that he had long known this disease of sore teats, and that twenty years ago he had had the sores on his fingers, just in the same way as the lads now on the farm. He added, he had no fear of milking the cows because he was sure he should not get it again. I then asked him to tell me exactly what occurred in the teat from the very first, and he said that it began as a hard pimple on the red teat, that this got a white head, and then there came a blister with watery fluid, which was subsequently broken in the milking. Another cowman added that he had seen the watery fluid get like "brainy stuff" before the blister was broken. Thus, the history of what occurs must be as follows:—First, there is a papule and then a vesicle, with first clear and then turbid contents. The vesicle on or before the turbid stage is ruptured by the hand of the milker, and the normal course of development of the pock is interrupted. The irritation of milking twice daily causes extensive ulceration and consequent formation of large fissured crusts. And thus, instead of getting well in about a fortnight, the disease is prolonged for four or five weeks or longer, and when finally healed there is an irregular scar. It is the hand of the milker which is responsible for the striking differences in appearance from the normal pock, such as the absence of pustule and pitting, but as for the reported absence of the initial papule in the Hendon cases, this is easily accounted for by Dr. Cameron's admission that for the earlier symptoms he relied on the statements of others, and no doubt these accounts were incomplete, as in the milkers' first description to me. On returning to London in the evening, I confided my convictions to Dr. Curnow, and asked his advice as to bringing the boy to London. Dr. Curnow very kindly arranged to have him admitted to the Seaman's Hospital, Greenwich, and on the following day, December 3rd, I persuaded the boy to accompany me there so as to have him under observation. I shall not trouble you, Sir, with full details of this case; suffice it to say that it was a most typical pock, and that lymph taken from the vesicle produced in calves typical vaccinia.

Diagnosis from Spurious Cow-pox.—The characteristic development of the pock on the boy's face and the production of typical vaccinia in the calf with the lymph were the conditions necessary for proving conclusively that this disease was the true cow-pox. The spurious forms are local eruptions on the teats, and are some of them communicable to the hands of the milkers. They were recognised by Jenner¹, Hering², and Ceely³, and stress was laid on the necessity of being able to distinguish them, as they afforded no immunity from small-pox. There is only one form, the white or blister pock, which is likely to create any difficulty in diagnosis. This disease is of short duration; the vesicles are only sub-epidermic, attain their height in 24 hours, are not truly umbilicated, and have no areola. After bursting they form a thin scab. There is no fever.

General Remarks.—Now, Sir, the question may occur to you—Is this micrococcus identical with the virus of vaccinia? I am devoting my attention to this and to the study of any other organisms which may be present in the lymph. If it be true that the same streptococcus may be found in diphtheria, erysipelas, puerperal fever, acute suppurative, scarlet fever, improperly preserved milk, and perhaps, too, in foot and mouth disease, there can be but little doubt that we have only to deal with a micro-organism, which,

¹ *An Inquiry into the Causes and Effects of the Variolæ Vaccinæ*, etc., 1798.

² *Ueber Kuhpocken an Kühen*, 1859.

³ *Transactions of the Provincial Medical and Surgical Association*, vol. viii, 1840, and vol. x, 1842.

when cultivated and inoculated in healthy animals, is capable of setting up a septic inflammation. Indeed, the *post-mortem* appearances observed by Dr. Klein point in my mind only to septic complication, which may equally occur in cow-pox, in scarlatina, and in other febrile diseases. I think that the explanation of this micrococcus being found occasionally in scarlatina is that in severe cases with ulcerated throat, the blood is unable to cope with the invasion of micrococci from the surface lesion. If this be so, the opinion which I wrote early in 1886,⁴ concerning the micrococci which had been described in measles, applies also to this micrococcus, namely, that in this and in many other cases I only described these organisms as distinct species "from their association with particular diseases, not because they are believed to be causally related, for there is very little evidence in favour of that belief as yet, but purely for convenience of reference. In many cases they are probably only septic organisms which have found a pabulum in dead tissue, others appear to be identical with organisms which have been found in pus."

Conclusions.—As the practical outcome of this research, I would strongly urge that prompt measures be enforced for isolating diseased animals and preventing the spread of the disease through the herd. And as the milk is liable to be contaminated with blood, pus, and discharges from the teats, I consider that it would only be consistent with the most elementary rules of sanitation that only the milk obtained from the healthy cows in the herd should be sent into the market. Such measures, I trust, will lead to the alleviation of much suffering in the cows, insure greater cleanliness in the milk, and provide another source of vaccine for public use.

THE DIAGNOSTIC SIGNIFICANCE OF HÆMATURIA.

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HÆMATURIA is a symptom common to a number of pathological conditions, which differ essentially in their seat, nature, and relationships. In many of these it is a prominent, in not a few of them the sole prominent, symptom, while its differential diagnosis is beset with difficulties not only from the multiplicity of causes, but from the fact that there are a certain number of cases which can only be attributed to causes still unknown, or at best very obscure.

Blood may appear in the urine in a corpuscular or non-corpuscular form. The latter is called hæmoglobinuria, to distinguish it from corpuscular hæmaturia.

Detection of Blood in the Urine.—The diagnosis of the presence of blood colouring matter in the urine may be made by (1) the eye, (2) the microscope, (3) the guaiacum test, (4) the spectroscope; but the microscope alone is capable of differentiating hæmaturia from hæmoglobinuria.

It has been maintained by Dr. Wickham Legg, an author who has written ably on several of the obscurer problems of clinical medicine, that the blood corpuscles get broken up after the urine is secreted. He maintains that if the urine is examined immediately after leaving the body, corpuscles can always be found. My own observations, which I have had the opportunity of making under the most favourable conditions, do not support this view. Hayem has found free hæmoglobin in excess in the blood serum, while the well known icteroid colouring of the skin and conjunctivæ which sometimes appears, supports the view that the hæmoglobin is set free in the blood before it appears in the urine. I shall have to refer to this matter again, and I believe I shall show that Dr. Wickham Legg is so far right that hæmoglobinuria, as distinguished from hæmaturia, is not always present in the group of cases where chilling of the surface appears to be the essential factor in the production of attacks of bloody urine.

Having premised the necessity of microscopic examination for the differentiation of corpuscular from non-corpuscular hæmaturia, it may be broadly stated that blood in the urine, when in any quantity and chemically unchanged, presents a very characteristic appearance not likely to be overlooked or mistaken for anything else. But when the urine has remained some time in the bladder the bright red colour becomes changed to a dirty brown, giving to the urine a porter colour if present in quantity or a smoky tinge when in less amount. This

change is due to a chemical alteration of the hæmoglobin, which becomes converted into methæmoglobin by the action of the acid urine. Such dark urine may be confounded with that caused by other dark pigments, such as indican or pyrocatechin, which occasionally are present.

Unaltered blood in small quantity is not very visible; but by inspecting the urine in a glass with a good light we can recognise, not only its peculiar colour, but its characteristic dichroism, that is, by reflected light it appears red, while by transmitted light it is green.

The microscopical search for blood is so well understood now by all practitioners that it needs few words. If traces only are present the lowest stratum of urine should be examined after standing some time. The corpuscles undergo many changes in urine, swelling up so as to lose their biconcave form, or shedding their hæmoglobin, by which they alter in shape, appear vacuolated, and ultimately colourless. Such colourless discs may possibly be confounded with discoid oxalates and torulæ, but both these are smaller, the latter containing bright nuclei and being generally oval.

The Guaiacum Test.—This depends upon the ozone-carrying power of hæmoglobin. It is generally performed by adding one or two drops of fresh tincture of guaiacum to about a drachm of urine, shaking the mixture, and filling in about half a drachm of ozonic ether, which is a solution of peroxide of hydrogen in sulphuric ether. If hæmoglobin be present a blue colour appears. Another method is to dip strips of blotting-paper in the tincture and dry them. These are used by touching them with a drop of urine and a drop of ozonic ether successively. Turpentine which has been exposed to the air always contains ozone, and may be substituted for ozonic ether, but cannot be depended upon so well. Unfortunately, this test is not quite perfect. The urine of patients containing iodide of potassium gives a blue colour though no blood be present, while I have often observed that corpuscles are to be seen with the microscope when the chemical report says "no blood reaction." With respect to the latter fallacy two cautions may be given. The guaiacum tincture should not be kept longer than two months; and, secondly, the urine to be tested should be drawn up with a pipette from the lowest stratum, just as it would be for microscopical observation, as the corpuscles naturally sink to the bottom of the glass.¹

The spectroscope has scarcely become a clinical instrument at present, in spite of the labours of my friend, Dr. MacMunn, whose admirable book on medical spectroscopy is well known to you. If blood is present in solution the examination is easy, and may be made by holding the vessel containing the urine between the source of light and an ordinary pocket spectroscope applied to the eye, when two dark bands will be visible between Fraunhofer's lines D and E in the yellow and green of the spectrum; if the colouring matter is converted into methæmoglobin, a band in red will appear in addition to the other two. When the blood is present in an insoluble state the urine must be filtered, and the filter paper with the deposit upon it digested in alcohol and ammonia. This fluid should be examined, as in the other case, but if little blood be present the faintest possible shadow in the orange of the spectrum may alone be visible; on adding ammonium sulphide to the fluid the two bands will show themselves, but disappear when the fluid is shaken with air, to reappear on standing (MacMunn, *Spectroscope in Medicine*, p. 125).

The main purpose of this paper is to deal with renal hæmaturia, but the difficulties of differential diagnosis are so great, that I should be wanting in honesty if I dismissed as foreign to my subject those cases which depend upon other causes. I must therefore, at the risk of trespassing upon your patience, attempt to grapple with the subject in its entirety.

I think I may content myself with the bare statement of the fact that the urine of women is bloody during menstruation, and whenever there is vaginal or uterine hæmorrhage. Hæmorrhage from the urethra may be caused by villous growths, or in consequence of local congestion or injury. The blood is bright red, appears independently of micturition, or is not mixed with the stream, but occurs at the beginning or end of it, and is often accompanied by local pain or other symptoms.

Hæmorrhage from the bladder may be caused by stone, prostatic disease, villous or malignant growths, cystitis, ulcer, parasites (Bilharzia), etc. In stone, prostatic disease, and cystitis, the diagnosis is not difficult, as these conditions have well marked symptoms. The first two can soon be excluded by physical examination, while para-

¹ Dr. Michael Foster states (*Text Book of Physiology*, Fourth Edition, p. 715), that fibrin possesses the power of decomposing peroxide of hydrogen, giving a blue colour with the guaiacum test. I have not been able to obtain this result with well washed fibrin, but in any case fibrin is not likely to be met with in urine apart from hæmaturia.

⁴ *Manual of Bacteriology*, p. 201.