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BRITISH INDUSTRIAL ANTHRAX.

PART II.

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BACTERIOLOGY.

THE number of times that the presence of anthrax bacilli or spores has been detected in imported material is not large. Andrewes (1899) of St Bartholomew's Hospital found anthrax spores in dust shaken from hair taken at random from a suspected bale of Chinese mane hair, hydraulically packed and weighing 5 cwt. Dust taken from the centre of the bale was found infected even after it had been passed, while still hydraulically packed, through a Washington Lyons Steam disinfector.

Andrew (1900) found anthrax bacilli in a sample of Siberian tail hair, which came from a horsehair factory in Suffolk, and had given rise to a case of anthrax in Glasgow. The hair was undyed, but had been washed in cold water and cleansed by passage through a warm solution of soda and by hackling and drawing into lengths.

Webb and Duncan (1904) of Worcester (County Council Report) found anthrax bacilli in Chinese mane hair, in Russian hair and in Persian wool. Out of eight cases of China hair examined four were found infected. They also found anthrax bacilli in two samples of dust taken from large quantities of hair.

Balfour Stewart (1901) isolated anthrax bacilli from a Kurachee hide and from the dust from a Bombay hide.

MacFadyean (1903) also isolated anthrax bacilli from suspected oats, by making an infusion of the latter in sterile water, and inoculating one sheep and eight guinea-pigs. The sheep and three of the guinea-pigs died. He also isolated anthrax bacilli from suspected cakes.

Anthrax bacilli were isolated from the mud of a stream in Suffolk, into which the waste from a horsehair factory was discharged[1]. A mouse and a guinea-pig after inoculation with the muddy water both died of typical anthrax. Animals grazing on the pastures watered by this stream had died from anthrax.

During the past three years Dr Eurich (1908) and his assistant Mr Walter Willey have examined for anthrax nearly 600 samples of wool, hair, and dust—not blood-stained—with negative results, while 139 blood-stained specimens have been tested with the result that anthrax bacilli (often in great numbers) were found in 14·4 per cent.

Dr Eurich therefore pointed out that blood-stained material and the dust arising therefrom, with its scales of dried blood, are the means of spreading anthrax spores, and can be called "carriers" of anthrax. A close examination of eight bales of Van-mohair showed that wool etc., which past experience had shown to be especially dangerous, contained a larger percentage of blood-stained fleeces than the others.

Dust may prove dangerous in virtue of the brittle scales of dried blood clots derived from such tainted material.

Klein (1901) in examining samples of "China" tails and Russian manes soaked several grams of the material in sterile salt solution, which was then centrifuged and the sediment injected subcutaneously into guinea-pigs and mice. No indication of anthrax was found, but several of the animals died from malignant oedema.

Duncan's method of procedure was apparently similar to that of Klein's, but he found that the bacillus of malignant oedema was often present, and acting more rapidly than anthrax tended to mask it. In cases in which death was due to malignant oedema he removed the spleen, as soon after death as possible, and made cultivations from the central spleen pulp; if anthrax-like colonies developed, a second guinea-pig was infected from these. By these means Duncan says on more than one occasion he has found anthrax, although everything pointed to death from malignant oedema.

In my own research work, putting on one side the methods of isolating the anthrax bacilli by inoculating animals, a series of experiments was first made to determine the best method of isolating the bacillus. About 10 c.c. of sterile horse's serum was placed in a test tube, and infected from a pure culture derived from a cow that had died of anthrax. A few grams of Chinese bristles were then placed in this serum and the whole incubated at 37° C. for 24 hours, after

[1] *Ann. Report of Chief Inspector of Factories*, 1906, p. 291.

which the bristles were removed, and allowed to dry in a Petri dish. Another lot of bristles were similarly infected, using, instead of the horse's serum, sterile salt solution.

From both these artificially infected samples of bristles anthrax bacilli were isolated at various intervals of time. A small quantity of the bristles, about 10 to 20 hairs only, was soaked in sterile salt solution, heated to 40—50° C. and frequently shaken during half an hour. Agar plates were sown directly from this salt solution, using one loopful of the solution to each plate and making three strokes across the plate. After incubating for about 18 hours at 37° C. the plates showed a varying amount of growth; sometimes a more or less thick film spread rapidly over the plate obscuring any other colonies present, others (and the majority) showed a variety of colonies including more or less film.

Agar slopes were found to be of little use, the growth being usually too thick for distinguishing between the various colonies. On nearly all the plates thus made were colonies so like anthrax that it was always difficult to distinguish between them until sub-cultivations were made.

Many experiments were carried out in the hope of eliminating these bacilli without destroying the anthrax bacilli. Bristles were soaked in sterile salt solution for periods varying from half to 24 hours at temperatures from 45 to 60° C. with frequent agitation. These were centrifuged, and the sediment drawn into capillary tubes, and heated at temperatures varying from 80 to 99° C. in water baths. The capillary tubes were again centrifuged and plates made from the sediment.

Control experiments were done at the same time by treating old anthrax spores in a similar manner. In the end it was found impossible to eliminate either the anthrax-like bacilli or those that grew as a film over the plates, obscuring and checking by the rapidity of their growth the development of other bacilli, without at the same time eliminating the small quantity of anthrax likely to be present in any sample of bristles or horsehair.

In a similar manner experiments were made to eliminate these bacilli by incubating bristle samples in carbolic broth of a strength varying from 1 in 1000 to 1 in 1500, but without success.

The method finally adopted in each case was simply to soak a small quantity (1 or 2 grams of the sample) in sterile salt solution. This was warmed to 50° C. by means of a water bath, and was kept at about that temperature for roughly half an hour. Throughout this time the salt solution was frequently shaken. Agar plates were sown directly—one loopful to each plate as above described. In all 83 samples were in-

vestigated as follows; 44 samples of bristles and 10 of bristle dust were examined and 22 samples of horsehair and 7 of dust. The samples consisted of Chinese (several bundles of the dirty Tientsin riflings being examined), Russian, Siberian, German-Polish, Polish, Indian, French and German bristles. The horsehair consisted of Chinese manes and tails, Siberian manes and tails, Russian tails, South American tails, and mixed Chinese and Russian mane and tail horsehair and cow tails.

Spores of anthrax were not detected in any sample.

Considering that none of the samples consisted of suspected or blood-stained material, and the small quantity actually examined, this result was perhaps to be expected; at the same time it must be admitted that the method of examination did not with absolute certainty exclude the presence of anthrax, since in several instances plates were spoilt by film-like growths of bacteria rapidly spreading over the agar, and obscuring any other colonies present, and in the second place the presence in relatively large quantities of several different kinds of bacilli very closely resembling anthrax especially in their original colonies upon agar. All those colonies that were likely to be confused with anthrax were sub-cultured until proved definitely to be of other kinds, these bacilli in pure culture differing in certain respects from anthrax; and, having proved that anthrax spores can be detected by the above method of plate cultivation, it is a fair inference that anthrax was either not present in any of the samples, or, if present, in infinitesimal quantities.

From bristles and horsehair three types of anthrax-like bacilli were isolated which have been called A, A^1, and A^2.

Two examples of type A were isolated, both from Tientsin riflings, differing only slightly from each other in the rate of liquefaction of gelatine, and the readiness with which chains are formed.

Two examples of type A^1 were isolated, one from Indian bristles, and the other from German-Polish bristles.

Of type A^2 several examples were isolated from several different sources.

The characters of these organisms are given in Table I.

An endeavour was made to establish the identity of these three types of bacilli with that of other described bacteria. (See Appendix.)

In drawing comparisons between the anthrax bacillus and the above types of anthrax-like bacilli, it must be remembered that under certain circumstances anthrax does not spike in gelatine stabs, only regaining the property after growing the bacillus on blood agar at 37° C. for

TABLE I.

Type Name	Description	Gram	Spores	Motility	Original colony on Agar	Agar Slope	Gelatine Plate: Surface	Gelatine Plate: Deep	Gelatine Stab	Potato
A Type	Same size as Anthrax, ends rather rounded, chains found.	X	X	X	Rounded, darker centre, white surrounded with thin chains.	Luxuriant moist irreg. fluffy edge, chains in upper drier parts.	Irreg. dark masses at centre from which numerous spikes extend.	Round, with small spikes.	Feathery spikes more numerous near surface, slow surface liquefaction.	Thin and slimy.
A^1 Type	Same size as Anthrax, with rounded ends, forms chains & filaments broken with difficulty.	X	? x	? x very slightly	Round, white, flat with raised centre, edge shows fine chains.	Rounded at intervals, frills of chains run out.	Curled and wavy edge like Anthrax, surface not so curly.	Small granules.	Surface growth, little deep, very slight liquefaction.	Thick, pinkish growth.
A^2 Type	Same size as Anthrax, corners rounded, stains evenly.	X	X	X	Round, greyish, from edges fibres pass out, curl, thin, peculiarly like Anthrax.	Moist, slightly granular with fluffy edges.	White centre, with very numerous radiating spikes.	Deep granular balls.	Very rapid funnel liq., pellicle may form.	Thin, moist shiny white.

Type Name	Milk	Liq. Gel.	Gas	Indol	Nitrates	Glucose	Saccharose	Mannite	Dulcite	Gelatine Slope	Agar Plate	Broth	Pathogenicity	Heat 80° C.	Remarks
A Type	Slightly acid after 5 days, no clot.	X	O	X	O	O	O	O	O	Dry growth, edges like cracked ice, slow liq.	At first irregularly rounded with more opaque centre and folded edge, later bundles of irreg. wavy chains.	Slight cloud, no pellicle deposit, sticky white.	O	X	A^3 chains better marked.
A^1 Type	O	X	O	O	O	X c	X c	O	O	Dry granular, very little liq.	Round, numerous chains from edges.	Clear, tangled mass of chains at bottom.	O	?O	A^6 threads on gelatine more luxuriant, A^6 liquefies gelatine faster, A^6 potato slimy, thick and white, A^6 acid in milk after 4 days, A^6 chains more numerous and wavy, A^6 Mannite? diff.
A^2 Type	Ac. and coag.	X	O	O	X	X c	X c	X	O	Rapid liq., pellicle forms and is wrinkled.	Rounded cols., with numerous thin chains; these often form a network between the cols.	Cloudy, fairly well marked pellicle, stringy white deposit.	O	X	

24 hours; and further, the anthrax bacillus may frequently show rounded ends.

The A^1 type in many ways is the most like anthrax, and as far as could be determined certainly does not correspond to any known bacillus; though in several cases the descriptions of these non-pathogenic bacilli are meagre in the extreme. The A type also cannot be identified with any known bacillus though it closely resembles one or two, notably 15°[1]. There can be hardly any doubt that the A^2 type corresponds with the "*Bacillus anthracoides*" of Bainbridge[2], and it is quite possible it may be a variety of the *Bac. subtilis*. Mr Duncan considered an anthrax-like bacillus, which he isolated from horsehair, to be the *Bacillus subtilis*, and another anthrax-like bacillus, which he also isolated from horsehair, to be the *Bacillus mesentericus vulgatus* of Flügge. Neither the A nor A^1 type can however be said to closely resemble the last-named bacillus.

Disinfection.

The problem of the destruction of anthrax spores in raw materials without damage to these has still to be solved. It is necessary to find a disinfectant that will overcome the resistance of anthrax spores without injuring the material in any way; further, the price of such disinfectant must be low so as not, by increasing the cost of production, to diminish the power of competing with foreign firms.

The number of means of disinfecting anthrax germs is small; Koch mentions six substances capable of destroying spores of anthrax within 24 hours.

These are, chlorine, bromine, iodine, osmic acid, potassium permanganate, and perchloride of mercury.

The first five are useless, because they are either too expensive or must be used of such a strength (as 5 per cent. potassium permanganate, 3·3 per cent. chlorine or 1 in 10 bleaching powder) as to be damaging to the materials.

Recent experiments show that perchloride of mercury is extremely untrustworthy as it unites with albuminous matter to produce an insoluble compound devoid of germicidal powers. Further, it is extremely poisonous, and has a corrosive action on metals.

[1] *Report Local Government Board*, 1897–8, pp. 290—295.
[2] *Journ. of Bact. and Path.* Vol. VIII. p. 117, 1903.

Esmarch has shown that anthrax spores have retained their vitality after an exposure of 40 days to five per cent. carbolic, and later experiments confirm this result.

In experiments carried out in the Imperial Health Office at Berlin, turpentine oil was tried, but failed to satisfy the requirements. Formalin vapour also was found unsatisfactory, as for want of penetration it failed to destroy spores placed artificially on bristles.

Eurich of Bradford found a 1 % solution of formaldehyde an efficient disinfectant of bales of wool, opened in the bath; and this efficiency was not lost if the bath was used three times. In bales which had been steeped unopened disinfection was found imperfect. More recently he found that formic aldehyde (2½ %) subject to the absence of ammonia disinfected bales of wool after two hours steeping. Klein (1901) found that a solution of formalin, 1 in 15, killed anthrax spores in one hour, but failed in three quarters of an hour. The time taken to kill anthrax spores varied with the material to be disinfected.

In the German Health Office potassium permanganate above 2 % was found to damage the material, a strength which failed to destroy the spores; but if a 2 % solution was used warm, or boiling, for not more than fifteen minutes, with subsequent bleaching with 3—4 % sulphurous acid, spores were destroyed.

Sulphurous acid alone must be 11 % with a contact of 1—2 hours to be effective, or associated with moisture 5 % will kill in 24 hours.

In the products of the distillation of coal besides carbolic acid many bodies of a similar chemical constitution occur, and many mixtures of these are on the market, such as cyllin, izal, lysol, etc. Izal in 10 % solution kills virulent anthrax spores in ten minutes (Klein). Commercial cyllin is stated to have a Rideal-Walker co-efficient of 15, it has the advantage of being cheaper than most other disinfectants, and is non-poisonous; while albuminous and other bodies do not affect its efficiency. It is harmless to the skin, metals, wood, and is compatible with soap. Klein found that, taking 45 minutes as the time of exposure, cyllin, diluted 1 in 100 water, was equal to a solution of formalin in water of a strength of 1 in 15; and that cyllin is six times as powerful as formalin in destroying anthrax spores. The spores in this experiment were obtained from a fatal case of wool sorters' disease. Further, Klein found that 1 in 100 cyllin, with a contact of 1½ hours, disinfected efficiently samples of "China" tail and Russian mane horsehair that contained bacilli of malignant oedema, but no anthrax.

For the purpose of the experiment this was satisfactory, as malignant oedema and anthrax are equally resistant.

Sample	Dilution	Time of exposure ¼ hr.	Time of exposure 1 hr.	Period of incubation at 37° C.
Formalin	1 : 15	Growth	—	4 days
,,	1 : 10	—	—	,,
Cyllin	1 : 100	Growth	—	,,
,,	1 : 50	—	—	,,

Eurich found that cyllin 1 % will destroy anthrax spores on wool after steeping one hour.

Boiling anthrax spores in water is effective, if sufficiently prolonged. In the Imperial Health Office at Berlin very resistant anthrax spores on silk were invariably destroyed by three hours boiling; less than three hours gave uncertain results. Further, it was found that the germs which survived boiling were attenuated, as proved by the inoculation of mice; death being delayed to the fourth or fifth day. As men are much less susceptible to anthrax than mice, the danger to the human subject from spores which have been boiled for some time is therefore small. In favour of boiling it can also be said that it is an admirable method of cleansing raw material; and it seems to be largely carried out in Germany both for many varieties of bristles and horsehair. In England, as will be shown, it is impracticable for bristles, and damages horsehair.

Duncan has also shown that though freshly developed anthrax spores can be destroyed by ten minutes in boiling water, yet when contaminated with grease, dirt, and dried animal discharges as in hair, they survive thirty minutes boiling.

With regard to steam, Legge (1906) states that to be effective it must be in contact with the material (in a loosened condition) for a sufficiently long time, and at a sufficiently high temperature; but, in order that the material may not be injured, this temperature must not exceed certain limits. Further, the conditions under which the steam is used, whether saturated or superheated, whether as current or as confined steam, the degree of its pressure and the consequent temperature within the apparatus to which the material becomes exposed, the presence or absence of air, are all of moment in determining efficiency. Disinfection is brought about by the steam coming into contact with a colder surface, i.e. the raw material, on which it condenses, and in so doing gives up its latent heat (sufficient to raise from 15 to 16 times its own weight of wool from 0° F. to 212° F.). Experiments carried

out at Berlin by the Imperial Health Office led to the following conclusions:—

(1) That spores of anthrax on horsehair were destroyed by exposure to current steam for half an hour at ·15 atmospheres ($2\frac{1}{4}$ lbs. = 218° F.).

(2) That this method of disinfection if carried out accurately and carefully is practicable for all except white horsehair, and this may be steamed if subsequently it is immediately well washed and bleached; it is also practicable for some kinds of bristles, i.e. these raw materials are not damaged for the purposes of manufacture; loosening the bundles was found to make but little difference, but in order that disinfection may be successful it is necessary that:—

(*a*) The disinfecting machine be of such construction as to secure an even temperature and pressure throughout. The steam should enter from above, then the cold air, being heavier than steam, is pressed out more evenly and the condensation is less. It is inadvisable for the apparatus to stand in the open, as this leads to greater condensation; it should be warmed before use, and the steam should enter slowly.

(*b*) In order to prevent damage to the raw materials, the means of controlling temperature and pressure must be accurate; therefore skilled and constant attention is necessary.

(*c*) Small quantities only (as for example a Russian bale) should be disinfected at a time, in order that the whole of the hair may be exposed to the same temperature.

Many experiments have been carried out in steam disinfection of hair by Webb and Duncan of Worcester (1904). As a result of the first series of experiments, it was found that dust shaken from hair that had been subjected to a temperature of 245° F., in a steam disinfector while bundled, was sterilized. A later series did not confirm this, as dust from carding hair that had been thus steamed still contained spores of anthrax. Hence it was concluded that the hair must be in a loosened condition, or else the steam will not penetrate the bundles. The drier the steam the less damage to the raw material but the less is it likely to destroy the spores. Experience shows that a temperature of 226—230° F. is as effective as higher temperatures.

Great care and constant supervision are necessary to secure satisfactory results, and steam cannot be regarded as absolutely certain in effect, though the great bulk of the spores are destroyed, and the vitality of the remainder diminished; after steaming inoculations sometimes took seven or eight days to kill guinea-pigs.

In answer to some questions as to the effect on horsehair of

different methods of disinfection, Mr Webb gave me the following information. It is not strictly true that steaming does not damage horsehair; even in half an hour the elasticity is reduced, and the material becomes more brittle, but not enough to be serious if the quality of the hair is good. Damp heat ruins hair. The dampness of normal pressure would be almost worse than a somewhat higher and drier one.

Steaming white hair turns it slightly yellow, and as it is naturally inclined to this colour, it is depreciated in value, because the yellow colour cannot be removed by subsequent bleaching. Mr Webb's firm disinfects many tons of hair per annum, and his experiments as to steam disinfection, the results of which are briefly given above, exactly corresponded with those of Signor Carlo Pacchetti of Milan; although each worked in ignorance of the other's methods.

Mr Webb says boiling damages the fine ends of hair, affecting the weaving of certain soft classes of hair, causing the ends to break off, and must be excluded as a means of disinfection. The frizzling up of the fine ends of long tail hair in boiling may be due to prior treatment with too strong alkali; this must be reckoned with in any process of disinfection.

Mr Webb states that he has found cyllin in the proportion of 1 in 250 ineffective. In his experiments horsehair was immersed in water in a tub, and the tub was placed in a water bath, which was heated by blowing steam through the water until the temperature in the tub reached 80° F., which favours the germination of the anthrax spores. After eight hours the water in the tub was found swarming with anthrax bacilli. In the place of the water in the tub, horsehair was immersed for twelve hours at the same temperature in a solution of cyllin of varying strength, from 1 in 1000 to 1 in 250; in each case the anthrax bacilli were found diminished in number, but not destroyed. Long immersion of horsehair in water up to 160° F. certainly does not hurt the hair.

Mr Webb's experience of formalin is small; he has found its powers of penetration slight.

Cyllin is now used in various ways by several manufacturers as a disinfectant of horsehair. One London firm immerses horsehair in 1 in 100 cyllin, and water at 66° F., for one hour, the larger bundles being opened out; they state that it does not in any way damage the hair. Another large firm in the Eastern Counties immerses horsehair in 1 in 500 cyllin, heated before immersion to 160°—170° F. The time of

immersion is twelve hours at that temperature, and the weight of hair disinfected each time is 9—10 cwt; they state that stronger solutions gum the hair together; this however, it is said, may be obviated by the addition of a little alkali.

Through facilities kindly granted by a firm of brushmakers, who mainly prepare their own horsehair, it was found possible to carry out some experiments with regard to disinfection. This firm disinfects all horsehair, whatever its origin, by steam, with the following apparatus. A wooden tank is used, holding about 200 lbs. of horsehair, divided by a horizontal grating about two inches from the bottom; steam leaves the boiler at a pressure of 35—40 lbs. to the square inch, and enters the tank below the grating through a tube which has numbers of very fine holes in it. When full of horsehair, and ready for steaming, the tank is covered over with several layers of sacking. Each steaming lasts 20 to 30 minutes.

It was found when the bulb of a maximum thermometer was placed in the centre of the tank, loosely packed in among the bundles, that the highest temperature reached was 220° F.; when tightly tied into a small bundle and again inserted, 218—220° F. The temperature in different parts of the tank varies from 218 to 222° F. These experiments were repeated several times to ensure accuracy. Before the hair is removed the temperature is allowed to fall to 70° or 80° F. When removed the hair is found to be very fairly dry. This process was found effective in destroying anthrax spores artificially placed on bristles, as will be described later. The effect of steaming hair on three consecutive days was tried with the idea that anthrax spores not killed by the first or second steaming would perhaps develope into bacilli, which are killed so much more easily, and would succumb in the third steaming. It was found, however, to damage the hair. Steaming for only thirty minutes was found to make the hair curly and crimped, and increased the difficulty of working it; this would be more disadvantageous in weaving than in brushmaking. Steaming longer than thirty minutes ruined it for all purposes. Further, it is doubtful if in the absence of a suitable medium spores would develope into bacilli on horsehair.

Boiling both white and dark hair in two per cent. potassium permanganate for 15 mimutes, followed by subsequent bleaching in sulphurous acid, was tried. It was found that the boiling makes the hair curly and difficult to work; examined while wet nothing wrong was noticed, but when carefully dried the hair was found damaged, being brittle.

Before steaming the hair, sprinkling it with 1 in 100 and 1 in 50 cyllin was tried, using two gallons of the 1 in 100 and one gallon of the 1 in 50 to each tank full of horsehair, i.e. about 200 lbs. The hair was not found in any way damaged commercially, but any larger quantity damaged the hair. Hair immersed in cyllin of a strength 1 in 100 at 176° F. for half an hour was not found to be damaged, though sticky for subsequent working.

Steaming bundles of bristles was found to damage the bristles for some purposes, and also in nine cases out of ten the bundles burst; for this reason alone steaming is impracticable, as the cost of rebundling would be prohibitive even supposing it could be done in England as well, for example, as a Chinaman can do it. Boiling bristle bundles had a similar effect. In order to meet the complaints of the dust from workers on Chinese riflings, dipping both ends of the bundles in paraffin floating on the surface of water has been tried by one firm for some time with advantage. Numerous experiments were made with several liquids of low surface tension, similar to paraffin, in order to find one that would dissolve a disinfectant, carry it up into the bristles, and yet not damage the hair for working; but with slight success. Cyllin as a disinfectant proved useless, preventing the bristles working on the machines; the best results were obtained by making a concentrated solution of carbolic acid in commercial oleic acid, and mixing with paraffin in a strength of 1 in 10 or 1 in 20 of carbolic, but even this was found to make the bristles too greasy to get good results.

Table II contains a description of experiments carried out with reference to the disinfection of anthrax spores. It was found that (1) anthrax spores from an old agar culture were destroyed by steam at 100° C. in half an hour (Experiment 1); (2) anthrax spores artificially placed on bristles were destroyed by exposure to steam for half an hour on three consecutive days; after two days exposure they were much diminished, if not entirely destroyed. None were isolated after the first day's steaming, though anthrax-like bacilli of the A^2 type, being present after the first and second day's steaming, prevented the experiment being absolutely conclusive as to the complete destruction of anthrax spores. These experiments prove, at any rate, that intermittent sterilization is not sufficient to destroy all spores present in bristles; though apparently all anthrax-like spores were eliminated by the third day (Experiments 2, 3, 4). In Experiment 5, anthrax spores artificially placed on bristles were found to be efficiently disinfected when steamed

in the tank described on page 367. The infected bristles were placed in the centre of the tank enveloped in a small bundle of hair, and afterwards were found to be sterile. The temperature was 220° F.

The effect of 1 in 100 cyllin at a temperature of 60° C. with a contact of one hour was tried on old cultures of anthrax containing spores, and old cultures of the three A types. In the first (Experiment 6) the anthrax spores were apparently all destroyed; in the second (Experiment 7) anthrax developed after treatment with cyllin, but growth was much delayed. Of the A types, A^1 was destroyed by the cyllin, but A and A^2 types, though growth was generally somewhat delayed, were certainly not destroyed (Experiment 8). Anthrax-infected bristles treated in a similar manner with cyllin and also with a longer contact, i.e. $1\frac{1}{2}$ hours, appeared to be sterilized, as far as anthrax was concerned; but other bacilli, among them the A^2 type, easily survived the cyllin.

The use of artificial spores (laboratory specimens), in place of natural ones surrounded by grease and dirt making them exceedingly resistant, probably accounts for the different results obtained by Mr Webb in England, and the German Imperial Health Office; for the former used natural spores, and the latter artificial ones on silk, in a similar way that I used them on bristles; this probably accounts for the fact that in my own experiments steam was found effective in getting rid of the anthrax spores, though at the same time in Experiment 5 the steaming in the horsehair tank apparently destroyed spores of the A and A^2 types, certainly as resistant, if not more so, than anthrax spores.

Thus we may conclude that disinfection of horsehair by steam cannot absolutely be relied upon; but that with due care the number of anthrax spores may be diminished, and the vitality of the remainder lowered without appreciable damage to the hair.

That steam is ever likely to be certainly effective in disinfecting horsehair is improbable, since the damper the steam the better chance of destroying the spores, but the greater the damage to the hair; and the drier the steam the less chance of destroying the spores and the less damage to the hair. These antagonistic results produce a deadlock.

For bristles steam is useless as it bursts or loosens the bundles.

Boiling as a method of disinfection is useless, because in the time taken to destroy the spores, 2—3 hours, the material would be considerably damaged.

TABLE II. *Disinfection.*

No. of Exp.	Material	Apparatus	Disinfectant	Time exposed	Temperature	Method employed	Result	Control Expts.	Remarks and Conclusions
1.	Old agar culture, containing spores of Anthrax.	Anthrax spores in salt solution in test tube heated in autoclave.	Steam in the autoclave at 100° C.	(*a*) ½ hr. (*b*) ½ hr. 1st day ½ hr. 2nd ,, (*c*) ½ hr. 1st ,, ½ hr. 2nd ,, ½ hr. 3rd ,,	100° C.	A platinum loop was rubbed over the surface of the old agar culture. An emulsion was made in sterile salt solution after the disinfection, agar plates sown directly (*a*),(*b*),(*c*).	No growth was obtained from (*a*), (*b*), or (*c*).	Agar slope inoculated from unheated salt solution showed much typical growth of Anthrax (proved by microscope and cultivation).	The spores were evidently not very resistant.
2.	Bristles artificially infected with Anthrax through salt solution as described on page 359.	Bristles placed in dry sterile test tubes plugged with cotton wool and covered over loosely to prevent any water of condensation entering the tubes.	Steam in the autoclave at 100° C.	(*a*) ½ hr. (*b*) ½ hr. 1st day ½ hr. 2nd ,, (*c*) ½ hr. 1st ,, ½ hr. 2nd ,, ½ hr. 3rd ,,	100° C.	After heating in autoclave broth was poured over the bristles. As after incubation broth from (*a*), (*b*), and (*c*) became cloudy, agar plates were sown in each case.	No Anthrax was isolated. The colony most like Anthrax was a Bac. (A 15) of the A^2 type obtained from (*a*).	Some of the bristles before heating were soaked in warm salt solution and from this an agar plate was sown from which Anthrax was isolated, proved by cultivation and microscope.	While not absolutely conclusive without inoculating animals it is probable that most if not all the Anthrax was destroyed by 1st steaming. Anthrax-like Bac. present from both (*a*) and (*b*) but none evident from (*c*).
3.	Experiment 2 repeated again but bristles after heating were spread out on agar plates. No Anthrax was obtained.								
4.	Bristles artificially infected with Anthrax through horse's serum as described on page 358.	The same, but bristles were moistened with sterile salt solution before heating.	The same.	The same (*a*), (*b*), (*c*).	The same.	Bristles after steaming soaked in warm salt solution and agar plates sown.	Salt solution in each case was sterile.	The same.	It is possible that had the bristles been placed directly upon agar some growth might have been obtained though certainly the number of spores if any that survived must have been much diminished by the steaming.

5.	The same.	Bristles wrapped in paper embedded in bundles of hair of about 2 lbs. wt. which were then tied tightly. Bundles then placed in centre of tank full of hair as described on page 367.	Steam at 220° F. = 104·4° C. Steam leaves the boiler for the tank at a pressure of about 35 lbs. to the sq. inch.	(*a*) ½ hr. (*b*) ½ hr. 1st day (18 hrs. interval) ½ hr. 2nd day.	220° F. = 104·4° C. as tested by maximum thermometer. Bulb was placed in centre of a small bundle of hair of about 2 lbs. wt. Bundle then tightly tied and inserted in centre of tank full of hair.	Bristles (*a*) and (*b*) soaked in warm salt solution from which agar plates were sown. Both proved sterile. Bristles were then themselves spread out on agar but proved to be quite sterile.	Bristles (*a*) and (*b*) found sterile.	The same.	Papers containing bristles after removal from centre of bales found to be damp.
6.	Old agar culture of Anthrax containing many spores.	Anthrax spores in 1 in 100 cyllin in test tube in water bath.	Commercial cyllin 1 in 100.	1 hour.	60° C. temp. of water in water bath.	A platinum loop was rubbed over the surface of the old agar cultures, an emulsion was made in 1 in 100 cyllin in a test tube. After disinfection agar plates sown directly.	No growth could be obtained up to 5 days incubation.	As Experiment 1.	—

7. Experiment 6 was repeated in exactly the same manner, after 48 hours incubation growth was obtained on agar which was proved Anthrax by microscope and cultivation e.g. clear growth in Broth, non-motile Bacillus, slow liq. of Gelatine, growth in Gelatine Stab culture, etc.

8. Similar experiments to 6 were made using old cultures of Bacilli A, A^1, A^2, as examples of the types of Bacilli isolated from bristles; when growth took place it was with one exception found delayed. A and A^2 grew readily, A^1 not at all.

9.	Bristles artificially infected with Anthrax through salt solution as described on page 359.	Bristles in 1 in 100 cyllin in test tube in water bath.	Commercial cyllin 1 in 100.	(*a*) 1 hr. (*b*) 1½ hrs.	Temp. varied from 50° C. to 70° C. and one was tried at temp. of the room about 12° C. or 53·5° F.	Agar tubes were stroked directly in each case and also cyllin after disinfection was poured off from bristles, which were then placed in warm sterile salt solution and agar plates sown from this.	In each case and by each method and at both temperatures much growth was obtained though unable to isolate any Anthrax. Cols. most like Anthrax isolated all proved to be of A^2 type (one A 13). Growth did not seem to be delayed.	As Experiment 2.	—

There remains then immersion of the material in some chemical disinfectant, but up to the present no compound has been produced that can be said to be absolutely effective in destroying the spores without damaging the raw materials. Cyllin at present seems to be the best; the great objection to it is its stickiness, but it is now being used in one or two factories for the disinfection of horsehair. The strength must be not less than 1 in 100 for any chance of success in destroying the spores, and it is doubtful if this is sufficiently strong; but more concentrated solutions render the hair too sticky though it is said the addition of some alkali prevents this. The second point is that the temperature of the disinfecting solution should not exceed 120° F. (or 50° C.) for that strength. The time of immersion must not be less than 1 hour with bales loosened and spread out, but a longer contact is desirable.

Eurich reports favourably on Leach's fluid for disinfecting bales of wool, the strength should be 2 % and the steeping last for an hour.

Further experiments as to the use of formalin under slight pressure and in solution may lead to better results.

Bristles are partly prepared and bundled and it is not practicable in most cases to untie the bundles before use, so that effective disinfection is very difficult; however, from what has been already written, it is evident the danger of infection from bristles is very small, and the method described above of using paraffin, by fixing the dust, should materially diminish even that small risk.

In addition to disinfection of raw materials much may be done to diminish risk by suitable regulations for workshops and factories in which dangerous materials are used.

Table III compares the English and German regulations for the manipulation of horsehair and bristles. There is reason to doubt if the German regulations are properly carried out.

Since the nails frequently act as spore carriers, it is advisable that gloves should be worn in processes preliminary to disinfection, and that the nails should be cut short, and that in washing a disinfectant, as cyllin, should be used with the soap. The use of the nail brush should be insisted on, also a plentiful supply of dry towels to prevent risk of chapped hands, thus leading to further risk. Each factory or workshop should be compelled to provide means for dressing any wounds or abrasions on exposed parts and keeping them covered until healed. The services of a medical man should be retained, in order that any suspicious case may be seen early by him, and, knowing the patient's employment, he may be able to make an early diagnosis, and to apply

the appropriate remedies in time. Also any employee absent from work should be traced by the employer at once, and if the absence is from illness of any kind, the medical man connected with the factory should visit the patient promptly. Respirators for manipulation of undisinfected horsehair are necessary. Mr Webb has known of two cases of internal anthrax and possibly three, and requires men handling raw materials to wear them. Pacchetti also requires his men to use them. Even in the wool trade anthrax recurs in "patches" after long freedom from it.

It is advisable, in issuing regulations, to name one or more disinfectants for personal use, and for disinfecting floors, walls, etc.

Premises of all kinds, however old, are used for factories and workshops, especially for brushmaking. It should be compulsory for employers to provide suitable accommodation, so that dust and waste can be completely removed by wet methods.

The English regulations have not been in force long enough to determine the effect in reducing the number of cases of anthrax, and it is impossible, owing to the absence of notification in Germany, to ascertain definitely if a reduction has taken place there.

In Nuremburg, one of the chief brushmaking towns in Germany, the regulations are carried out, all raw materials being disinfected by steam; yet cases of anthrax still occur, though, considering the great increase in the number of people employed there, relatively less in number.

England and Germany are the only European countries requiring disinfection of raw materials. However, in the works of Signor Carlo Pacchetti of Milan, very large horsehair manufacturers, employing about 700 work-people, steam disinfection of dark horsehair is carried out, while white hair is washed in soda and boiled in potassium permanganate, and subsequently bleached according to the German regulations. Also a physician attends every morning to treat accidents and slight ailments, keeping careful watch for appearances or conditions suggesting anthrax, while a surgeon's room is fitted up for the bacteriological investigation of anthrax, and a supply of Sclavo's serum is kept.

Signor Pacchetti states that he has no fear of the disease among his work-people, as he has seen so many successes in dealing with it by the above methods. Cases of anthrax in the earliest stages are caught, treated, and recover, without cessation of work for more than a day or two.

TABLE III.

Table showing English and German methods and rules for the disinfection and manipulation of Horsehair and Bristles.

England. Factory and Workshop Act, 1901. Regulations for the use of Horsehair came into force Jan. 1st, 1908.

Germany. Section 120 *e*. Industrial code 1902 came into force Jan. 1st, 1903.

1	2	3				4	5	6
		Disinfection						
Country	Material	Steam			Other	Register	Storing non-disinfected material	Operations previous to disinfection
England	Tails and manes of horses as imported from China, Russia, and Siberia, whether raw, partially, or wholly prepared.	Steam at 212° F. for ½ hour. Material must be loosened and spread out and fully exposed.			By other means under certificate. (1) Cert. must be signed by the Director of a Bacteriological Lab. (2) Cert. must state the method which must be able to destroy Anthrax spores in all parts of the horsehair. (3) Copy of cert. must be put in Register. (4) Cert. must be approved by Sec. of State.	A Register must be kept and for each consignment must be entered: (1) Wt. of materials. (2) Date of receipt on premises. (3) Country of origin. (4) Whether raw, partially or wholly prepared. (5) Method of disinfection. (6) Date of same and whether on premises. (7) Name of vendor of material.	Separate storing room for non-disinfected material only.	Opening and preliminary sorting only in a special room and over efficient screens. (At a rad. of 18″ velocity of extraction 300 lin. ft. per minute.)
		Steam	Potass. permang.	Boilin				
Germany	All foreign horsehair, cowhair or goathair, pigs' bristles and pigs' wool. *Exceptions* see below *.	Current steam at ·15 atm. (about 220° F.) for ½ hr.	Boiling for ½ hr. in 2 % pot. permang. and subsequent bleaching in 3—4 % H_2SO_3.	Simple boiling for 2 hrs.	Other methods may be used but they must be approved by the Imperial Chancellor.	Register must contain list of exceptions with grounds therefor. Statement of treatment subjected to abroad, also the source, amount, and country of origin of all materials, duration and mode of disinfection, vouchers to be kept in case of public disinfection. Register to be examined each Feb. 1st.	Special storing room as above with separate entrance. Room to be kept locked.	Unpacking, cutting from docks, conveyance to apparatus, tying bristles in bundles, sorting for purposes of disinfection, all to be done in special rooms.

TABLE III (*continued*).

Country	7 Other operations	8 Treatment of dust from operations in cols. 6 & 7	9 Use of overalls etc.	10 Provisions as to food	11 Surgical provisions	12 Lavatory accommodation	13 Cautioning notices	14 Age limit
England	Willowing and dust extracting machines must be covered and provided with efficient screens.	Dust to be discharged in special manner & burnt. Each extracting shaft and spaces under opening & sorting screens to be cleaned out once a week.	Suitable overalls and head coverings, respirators fresh or cleaned every week to be used for 6, 7, 8. Separate storing room for overalls. Separate cloak rooms for workpeople.	Either meal rooms to be provided or else works must be shut down; smoking, eating, and drinking not allowed on the works.	Means of treating wounds and scratches, prevention of people working with wounds, etc.	Provision by employer of Lavatory with hot and cold water, towels, soap, nail brushes.	Cautioning notice to be placed in the works.	No person under 18 allowed to be employed on non-disinfected material.
Germany	Mixing, willowing, and hackling the same as above, sorting and hackling in a special room.	Much the same.	Practically the same except respirators are not mentioned.	The same.	The same.	The same.	The same.	No young person as above.

* (1) If bought already disinfected in the prescribed manner at home or effectually from abroad and if kept separate from non-disinfected material.

(2) White bristles to be further bleached, or previously bleached as French, if kept separate as under (1).

(3) Any material which cannot according to present experience be disinfected without serious damage. This being a disputed point forms a considerable loophole for avoiding disinfection.

England. Other Regulations.

Lavatory basin or 2 ft. trough to each 5 persons.

N.B. Draft Nov. 1907 made an exception in favour of white or light grey hair soaked in a warm alkaline solution and wet hackled.

Also mentions daily cleansing of the floors.

Germany. Other Regulations.

Solid impervious floor rendering removal of dust by wet method easy. Wooden floors to be planed smooth and protected against wet.

Walls and ceilings unless washable to be lime-washed annually. New or extension of premises in dusty occupations 530 cub. ft. air to each person.

Moist washing of floors, etc. daily, ventilation of workshops twice a day, burning of coverings of bales, dung or dirt.

Table IV is copied from one by Prof. Ascoli (1906), Physician to Messrs Pacchetti, showing the method of treating and using hair.

Treatment.

The treatment of anthrax depends on the nature of the disease and the position of the lesion.

The only treatment holding out any hope of success in internal cases is the early intravenous injection of serum; in cases of malignant pustule we may combine local with general treatment including injection of serum.

Local treatment should consist in cauterization or excision whenever possible, and in most cases the former at any rate is possible. Other measures, such as the injection round the pustule of 2 % carbolic acid or of iodine, the taking of iodine internally, the use of ipecacuanha both locally and internally are not likely to be of much advantage. Prof. Ascoli strongly recommends cauterization; with a red-hot iron the pustule should be burnt widely and deeply, including a little of the healthy tissues around and below. Excision, except in the case of a very skilful operator, opens the door to possible generalisation. Cauterization is better, though a bad scar would remain in a serious case. In the early stages at any rate no method can vie with this.

The treatment of anthrax by serum (discovered by Sclavo in 1895) has now been tried sufficiently long to enable an idea of its value to be formed. Sclavo (1903) collected figures for cases treated in Italy by the end of 1903 with serum, i.e. 164 cases, 10 deaths, mortality 6·09 % as compared with 24·1 % for the whole of Italy. Legge, in March 1905, had collected 69 cases with only two deaths; in one of these the injection of serum was delayed, and the second was the subject of other diseases besides anthrax. All but two of these cases occurred in Italy.

Since 1904 there have been not less than 91 cases in Great Britain treated with serum (Table V), of whom 29 died, per cent. fatal 31·8; 33 of these cases were treated with serum without excision or cauterization, and of these 12 died, per cent. fatal 36·3. The percentage of failures with serum alone decreased in 1906 and especially in 1907, thus:—

Year	Cases	Deaths	
1904	2	1	50 % fatal.
1905	14	7	50 % ,,
1906	10	3	30 % ,,
1907	7	1	14·3 % ,,

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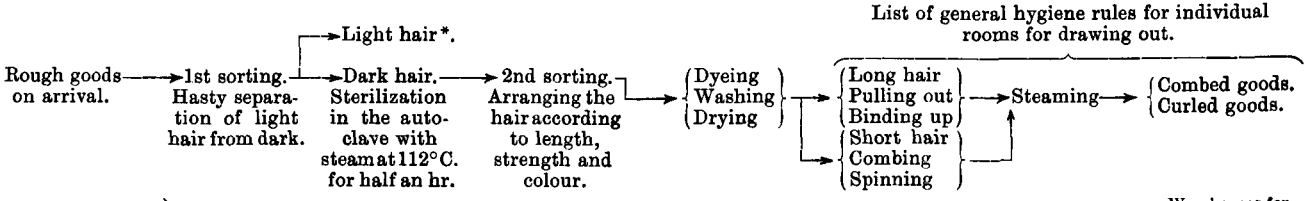
TABLE IV.

Of the working up of animal hair with relation to the measures of industrial hygiene practised in the establishment of Carlo Pacchetti and Co.



Storehouses for reception	Disinfecting places	Sorting rooms	Washing, Dyeing, Drying	Spinning rooms	Dyeworks	Warehouses for finished goods and despatch
Individuals are subject to the general hygienic rules placarded in the establishment, chiefly: (*a*) It is forbidden to carry food into workrooms; (*b*) It is compulsory to report cutaneous injuries to the doctor of the establishment. A true list must be distributed to the heads (of the firm) and to the Sanitary officers of the establishment.	Individuals on the Staff are under the direct surveillance of the Medical officer for industrial hygiene of the establishment. Respiratory masks. A washing place, and disinfecting solutions on the works. General hygienic rules.	A. Department for disinfection. The goods are received in sacks or boxes with the countersign of the Medical officer stating that disinfection has been performed. B. Department for individuals for the observation of general hygienic rules. C. Special provisions. Respiratory masks, Ventilators, Tables of assorted goods in decreasing qualities.	Special hygienic rules.	Department for individuals. Ventilation. Respiratory masks.	Wrought goods are passed once again through the autoclave at 120° C. for 20 mins.	General hygienic rules.

* We omit to follow up the manufacture, although intricate, to avoid complicating the diagram. The hygiene measures applied are analogous to those for dark hair.

In 1904 there were 10 cases of anthrax (3 fatal) treated with serum with or without other treatment. Two were treated with serum alone. In one (1) after the injection of an initial dose of 40 c.c., there was rapid improvement but slight scar eventually resulting. In the second (2) the patient was in a hopeless condition at the time of the injection. In a fatal case (4), in which excision and serum formed the treatment, the patient was comatose at the time of the injection and died shortly afterwards. In the third fatal case (5) the patient died 30 hours after excision, having received only 20 c.c.

In 1905 there were 31 cases in which serum with or without other treatment was used. Of these 13 were fatal, 14 were treated by serum alone, and of these 7 died, 4 of the 14 were internal and were all fatal. In two of these internal cases (24 and 40) injections of serum were only made just before death, in the third internal case (27) 40 c.c. were injected, but only 12 hours before death, and in the remaining internal case two injections of 40 c.c. were made, the first 18 hours before death. Of the other three fatal cases, all (external) treated with serum alone, two (15 and 28) were comatose at the time of injection, and died shortly afterwards, and one (25) died from meningeal hemorrhage after 150 c.c. had been injected, during 49 hours of treatment, by subcutaneous and intravenous methods. Of the six fatal cases, in which excision was performed as well as serum injected, one (29) was fatal eight hours after the injection of serum, another (31) 16 hours after injection of serum, and a third (37) five hours after injection of serum; a fourth (20) was injected with serum the day before death, but it was the sixth day of the disease. In the remaining two cases, (13) and (14), 70 c.c. and 80 c.c. respectively failed to save life, though treatment lasted 51 and 36 hours, commencing on the second day of the disease in each case.

Three cases (16, 19, and 36) that recovered developed slight secondary rashes; in two other cases (21 and 38) there was much sloughing of tissue, despite the injection of serum. In a case (33) at the time of the injection, anthrax bacilli were cultivated from the pustule; 19 hours after the injection they had absolutely disappeared. In several cases, notably (17), (19), (22), (33), (39), (41), rapid improvement after injection of serum was very marked.

In 1906 of 27 cases treated with serum 9 were fatal; 10 of these were treated with serum alone with 3 deaths. There were 3 internal cases, and injections of 200 c.c. probably saved the life of one man, as the case (66) was severe; it must be remembered, however, that no bacterio-

logical examination was made. In the second of the internal cases (65) the serum treatment seemed at first to cause much improvement, when a sudden collapse ensued followed by a fatal issue. In the third internal case (67), in spite of injections of 80 c.c. subcutaneously, and 50 c.c. intravenously, there was no reaction; death ensued within 60 hours of the first injection.

In case (58) there was ulceration in the intestines as well as a malignant pustule, probably due to separate infections, as no other parts were affected; and 20 c.c. of serum had no effect. In case (52) there was similar ulceration, and the injection of serum was not made until 14 hours before death. Of four other fatal cases, two (53 and 64) died within 24 hours of treatment commencing. The third (45) was evidently moribund when the injection was made; and the fourth (44) had two pustules, and only received 20 c.c. though 10 of them were injected intravenously. In case (49) there was marked and rapid improvement after injection, though the case was a severe and unfavourable one.

Another patient (62) recovered after 190 c.c. had been injected, and in (68) there was rapid improvement after injection of 80 c.c.

Sufficient details are lacking as to the cases treated with serum in 1907. 23 cases in all were treated with serum, with or without other treatment; four died. Of these cases, seven, of which one died, were treated with serum alone; in this fatal case (80) death was attributed to pneumonia.

In case (77) 100 c.c. failed to save and in case (88) the disease was probably too far advanced owing to faulty diagnosis for the injection to be of much value. Case (79) was a severe one, but improvement followed the injection.

Thus it will be seen that the mortality of cases treated with serum in England is very considerably higher than that of those Italian cases collected by Sclavo (1903) and Legge; and is also higher than the mortality of all cases of English Industrial Anthrax, previous to the introduction of serum, i.e. previous to 1904. Thus:—

Mortality of all cases treated with serum in this country	= 31·8
Mortality of all cases treated with serum only in this country	= 36·3
Mortality of Sclavo's (1903) cases of serum treatment	= 6·09
Mortality of Legge's cases of serum treatment	= 2·9
Mortality of cases previous to the introduction of serum (all cases of Industrial Anthrax, England 1889—1903)	= 26·5

How are these differences to be explained? Possibly as follows:—

Examining in detail the cases treated with serum during the years 1904 and 1905, because of the fuller details of cases in those years, seven treated with serum alone were either comatose, or in a hopeless condition, when the first injection of serum took place, and died within 24 hours of the first injection. In five cases, treated with excision and serum combined, the disease was similarly far advanced; while one case treated by combined excision and serum only received 20 c.c. of the latter, and another died from meningeal hemorrhage, making a total of 14 cases. Now in 1904 and 1905, there were 41 cases in which the serum treatment was used with 16 deaths; and if we deduct, as we fairly may, the above 14 fatal cases, which were either dying at the time of injection, or in one case about to die of a complication, we have 27 cases with two deaths treated by serum alone, or in conjunction with other methods, in 1904 and 1905. This gives a percentage mortality of only 7·4, which closely corresponds with Sclavo's (1903) figures. Among Sclavo's (1903) cases were only two or three in which treatment was commenced when in a hopeless condition. His fatal cases being only 10, the mortality of 6·09 would have been considerably lower had these been excluded.

Further, undoubtedly an insufficient amount of serum was injected, especially in the earlier cases; and it will be noticed that an increase in the amount injected corresponds to a fall in the mortality from 50% in 1904 to 14·3 in 1907.

The way in which the serum acts is disputed. Sclavo (1903) regards it as stimulating the defensive activity of the phagocytes, an anti-bacterial rather than an antitoxic action. Andrewes, from observations of case (33), infers that the serum exerted a powerfully bactericidal action; increase of the local oedema, after injection, possibly depended on the liberation of an intra-cellular toxin from the disintegrated bodies of the bacilli, which 19 hours after the injection could not be cultivated from the pustule. Prof. Ivo Bandi (1904), from observation of two successful cases treated with a serum of his own prepared in a very similar manner to Sclavo's (1903), concludes that the action is anti-bacterial, because of the immediate arrest of the progressive invasion of the organism by the bacillus, and antitoxic, because of the sudden improvement in the general condition and the complete and immediate restitution of the renal function.

Sclavo's (1903) claims as to the effects of anti-anthrax serum may be summarised as follows:—

(1) Anti-anthrax serum even in very large doses is innocuous and can be well borne even when introduced into the veins.

(2) No case taken in an early stage or of moderate severity is fatal if treated with serum.

(3) With serum some cases are saved when the condition is most critical, and the prognosis almost hopeless.

(4) When injected into the veins the serum quickly arrests the extension of the oedematous process so as to reduce notably the danger of suffocation, which exists in many cases where the pustule is situated on the face or neck.

(5) The serum, if used soon enough, reduces to a minimum the destruction of the tissues where the pustule is situated, and thus avoids creating deformity.

(6) In some situations of the pustule, as the eye-lid, serum must be used in preference to any other treatment, it being the only one which holds out hope of success without permanent injury, and in cases of internal anthrax the early injection of serum intravenously is the only remedy likely to be successful.

The serum may be obtained from Elia Coli of Siena in Italy in 10 c.c. tubes. 30 or 40 c.c. should be injected in 3 or 4 lots under different parts of the skin of the abdomen, the usual precautions as to sterilizing the skin and syringe being observed. After 24 hours, if there has been no improvement, either in the general or local conditions, further injections of 20, 30, or 40 c.c. should be made.

In severe cases 10 c.c. may be injected into a vein on the back of the hand and repeated in 2 or 3 hours. A rise of temperature following the injection is to be regarded as a favourable indication. Sometimes a rash developes with or without febrile symptoms 3 to 8 days after treatment has commenced. This is not peculiar to the anti-anthrax serum, but may occur after injection of any other kind of serum. In the rare instances where it occurs, it is unimportant. The serum will keep for two years; if sterile and kept in a dark and cool place it will not lose its efficacy, though a slight deposit may occur. Sclavo has since advocated much larger initial doses injected subcutaneously, and it is probable that better results would be obtained if 100 c.c. were first injected, followed, after an interval sufficient for the body to re-adjust itself to the altered conditions, by other injections.

TABLE V.

Cases of Anthrax treated with Seru

No. of Case	Year	Locality	Sex	Age	Industry	Occupation	F=Fatal	Rm=Recovery slight	Rs=Recovery severe	Nature of Anthrax and situation of pustule	Verificatio
1	1904	London	M	31	Horsehair	—	—	Rm	—	Malar eminence of cheek	Culture, et
2	,,	—	—	—	—	—	F	—	—	Malignant Anthrax oedema	—
3	,,	Kidderminster	F	35	Woollen	Husband wool sorter	—	—	R	Right angle of mouth	Culture, et
4	,,	N. Stafford	—	—	—	—	F	—	—	Hand	—
5	,,	—	—	—	—	—	F	—	—	Neck	—
6	,,	Bradford	—	—	—	—	—	—	R	—	—
7	,,	,,	—	—	—	—	—	—	R	—	—
8	,,	London	—	—	—	—	—	—	R	—	—
9	,,	—	—	—	—	—	—	—	R	—	—
10	,,	—	—	—	—	—	—	—	R	—	—
11	1905	Bradford	M	61	Wool combing	Wool runner	F	—	—	Internal (pulm.)	—
12	,,	,,	M	40	,,	Opening bales	—	Rm	—	Neck	Doubtful case
13	,,	,,	M	47	,,	,,	F	—	—	Neck	—
14	,,	,,	F	36	,,	Opening, untying knots	F	—	—	Cheek, rapid generalisation	—
15	,,	,,	F	42	,,	Finishing boxwinder	F	—	—	Under chin	—
16	,,	Bingley	M	35	Mohair spinning	Combing manager	—	—	Rs	No pustule, much oedema, right eyelid and face	No Anthr Bacilli fou on cultu
17	,,	Dewsbury	M	30	Blanket making	Blender, etc.	—	Rm	—	Left cheek	—
18	,,	Kidderminster	F	18	Spinning & carpet manuf.	Roving frame near carding machine	—	Rm	—	Left forearm	—
19	,,	London	F	25	Boot manfg.	Lining upper leathers	—	Rm	—	Cheek, typical 2nd pustule	Anthrax B not found culture
20	,,	Wellingboro'	M	31	,,	Heelbinder	F	—	—	Neck, much oedema of chest	—
21	,,	Bradford	F	25	Wool combing	Opening fleeces	—	—	Rs	Left upper eyelid, great oedema of face	Anthrax B found
22	,,	Kidderminster	F	?	Wife of woolcomber	—	—	Rm	—	Chin	—
23	,,	Bradford	F	42	Wool combing	Washbowl	—	—	Rs	Neck	—

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TABLE V.

in England to the close of 1907.

Possible source of infecting material	Treatment E. = Excision S. = Serum	Remarks. Particulars as to Serum, etc. (Serum injected subcutaneously unless otherwise stated)	Probable stage in days when case came under treatment	Various
—	S.	40 c.c., glands involved, inj. followed by slight rise of temp. and increase of oedema, rapid improvement. Eschar separates on 17th day, slight scar.	4th	*B.M.J.* Jan. 7, '05.
—	S.	30 c.c. inj. when patient comatose 4 hours before death.	10th	*Lancet*, March 25, '05. Legge, Milroy Lect.
Husband working on Persian	S. & E.	30 c.c. inj. in 4 lots on 5th day, discharged on 8th with healthy wound.	5th	*Lancet*, Feb. 4, '05.
—	S. & E.	Patient comatose when serum injected.	—	*Lancet*, March 25, '05. Legge, Milroy Lect.
—	S. & E.	2 injections of 10 c.c., death 30 hours after excision.	—	Ditto.
—	S. & E.	Rapid recovery.	—	Ditto.
—	S. & E.	Ditto.	—	Ditto.
—	S. & E.	Ditto.	—	Ditto.
—	S. & E.	Ditto.	—	Ditto.
—	S. & E.	Ditto.	—	Ditto.
Camel and Goat	S.	40 c.c. rept. same day, total 80 c.c., fatal 18 hours after treatment commenced.	3rd	—
Camel, Cow, Goat	E. & S.	40 c.c. on 21st day.	21st	—
Camel hair, E. Indian	E. & S.	40 c.c. on 1st day treatment, 40 c.c. on 2nd day treatment. Fatal within 51 hrs. of commencement of treatment.	2nd	—
Van Mohair, Persian	E. & S.	40 c.c. rept. once on 2nd day of disease, 40 c.c. on 3rd day, 30 c.c. 4th, fatal within 36 hours of treatment.	2nd	—
Camel hair and foreign grey wool	S.	40 c.c. on 2nd day of disease, patient then comatose, fatal shortly afterwards.	2nd	—
Van and Cape Mohair & Alpaca	S. carbolic	2½ % carbolic repeatedly injected, 40 c.c. 2nd or 3rd day of disease, 30 c.c. next day, improvement. Later developes pains in arms and legs and slight rash.	1st & 2nd	4 mos. after still unable to work & a yr. from the disease suffers from much oedema of face & neck.
E. Indian	E. & S.	3rd day excision, 4th 40 c.c. followed by slight rise of temperature, 5th day normal, discharged 17th.	3rd	*Lancet*, 1905, Vol. II. p. 1329.
Persian	E. & S.	5th day E. and 40 c.c.	5th	—
Tanned leather	S.	10 c.c. 2nd day of disease, 3rd day 10 c.c. every 2 hours up to 40 c.c., 4th day 20 c.c., marked improvement after injections, about 14 days later slight scarlet rash.	2nd	—
,,	E. & S.	E. 4th day of disease, serum 70 c.c. in 2 doses 6th day, fatal 7th day.	4th	—
Persian	S.	20 c.c. on 3rd day of disease, 10 c.c. on 4th, 50 c.c. 5th, 20 c.c. 6th, general condition improved after 2nd injection and oedema began to be reduced. Result, recovery with much sloughing and ectropion subsequently improved by a plastic operation.	3rd	*B.M.J.* 1905, Vol. II. p. 118.
usband working on Persian	E. & S.	30 c.c. on 3rd day of disease, discharged on the 8th day.	3rd	*Lancet*, 1905, Vol. I. p. 992.
obably Persian	E. & S.	10 c.c. on 5th day of disease, 10 c.c. 6th, discharged 16th day.	5th	—

TABLE V (*continued*).

No. of Case	Year	Locality	Sex	Age	Industry	Occupation	F = Fatal	Rm = Recovery slight	Rs = Recovery severe	Nature of Anthrax and situation of pustule	Verification
24	1905	Bradford	M	22	Wool combing	Card feeding	F	—	—	Anthracoemia, no ext. lesion	Anthrax Bac. found in blood before death
25	,,	,,	—	57	,,	Top packer and warehouse	F	—	—	Forearm	—
26	,,	,,	—	37	Worsted spinning	Sorting	—	—	Rs	Upper arm, glands affected	—
27	,,	Saltaire	M	45	Wool spinning	Sorter	F	—	—	Internal (pulm.)	—
28	,,	E. London	M	42	Hides Docks	Dock labourer	F	—	—	Neck, oedema of chest, delirium	Anth. Bac. not found before or after death
29	,,	London	M	47	Fur & skin warehouse	Sorter and packer	F	—	—	Neck, much swelling	—
30	,,	Worcester	M	33	Hides	Liming in Tan-yard	—	—	Rs	Neck, oedema of chest, great collapse	—
31	,,	Liverpool	M	44	Hides Docks	Dock labourer	F	—	—	Neck, great oedema of chest	—
32	,,	London	M	35	Hides Wharfingers	Sorter	—	Rm	—	Neck	—
33	,,	,,	M	30	Horsehair dressing	Drawer of hair	—	Rm	—	Forehead, following injury, enlarged glands	Cultures and inoculation
34	,,	Queensbury	M	42	Mohair spinners	Packer	—	Rm	—	Left cheek	—
35	,,	Bradford	M	41	Wool combing	Willowing	—	Rm	—	Left eyebrow	—
36	,,	,,	F	26	,,	Card feeder	—	Rm	—	Neck	—
37	,,	,,	F	?	,,	Comb minder	F	—	—	Neck	—
38	,,	Bingley	M	30	,,	Washer	—	—	Rs	Hand and arm	—
39	,,	Liverpool	F	17	Woolbroker	Sorter	—	Rm	—	Forehead	—
40	,,	Bradford	M	41	Wool combing	Card jobber	F	—	—	Internal (pulm.)	—
41	,,	Kidderminster	F	16	,,	Spinning	—	—	Rs	Cheek	—
42	1906	Bradford	M	37	,,	Willeyer	—	Rm	—	Neck	Microscope, Anthrax Bac. found in pustule
43	,,	,,	M	51	,,	Washbowl feeder	—	Rm	—	Elbow	Anthrax Bac. not found in pustule
44	,,	London	M	31	Horsehair manuf.	Dresser	F	—	—	Neck & forehead, 2 pustules, Anthrax septicaemia	Culture, etc.

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TABLE V (*continued*).

Possible source of infecting material	Treatment E. = Excision S. = Serum	Remarks. Particulars as to Serum, etc. (Serum injected subcutaneously unless otherwise stated)	Probable stage in days when case came under treatment	Various
Persian only	S.	30 c.c. on 8th day of disease, 4 hours before death, only when comatose.	8th	—
Persian chiefly	S.	40 c.c. on 3rd day of disease, 35 c.c. on 4th, 40 c.c. subcut. and 35 c.c. intravenously on 5th, fatal 49 hrs. after treatment commenced, total S. injected 150 c.c.	3rd	Death due to Meningeal hemorrhage on 8th day of disease.
Angora Mohair	E. & S.	E., & S. 20 c.c. on 2nd day of disease, 20 c.c. on 3rd, 30 c.c. on 4th. Temp. normal after 4 days treatment.	2nd	—
Turkey Mohair, Alpaca	S.	40 c.c. on 5th day of disease, fatal 12 hours later.	4th	—
? Goods shipped through Oporto	S.	20 c.c. on 7th or 8th day, condition nearly hopeless when treatment began.	7th or 8th	—
American wolf, Australian opossum, China fox	E. & S.	E. 4th day of disease, S. 5th day, tracheotomy, fatal 8 hours after injecting serum.	4th	—
Morocco and Calcutta goat skins	E. & S.		4th	—
West African	E. & S.	30 c.c. 5th day of disease, no reaction, fatal 16 hours later.	4th	—
Elk hides, Straits Settlements	E. & S.	30 c.c.	23rd	—
Hair of all sorts except China manes	S.	40 c.c., no rise of temp. following injection, but for 2 days oedema increased, eschar separates 18th day, leaving hardly any scar, no Anthrax Bacilli could be cultivated from pustule 19 hours after injection.	3rd or 4th	*B.M.J.* 1905, Vol. 1. p. 296.
Turkey and Cape Mohair	E. & S.	40 c.c. on 6th day, discharged 18th day.	6th	—
Alpaca Mohair and Camel hair	Carbolic S.	40 c.c. on 3rd day of disease, discharged 13th day.	3rd	—
Persian locks	E. & S.	40 c.c. 2nd day of disease—secondary measles-like rash, joint pains, temp. etc. lasting 2 days after 14 days interval, temp. (after injection of serum) 105° F.	2nd	—
Brown Persian and Egyptian	E. & S.	40 c.c. on 5th day of disease, comatose, died 5 hours later.	5th	—
Van, Persian Mohair	S. Carb. Inj. 2½%	Very severe. Carb. inj. rept. every 4–6 hours for 4 days. 40 c.c. 3rd day, 40 c.c. on 4th day of disease—much sloughing and subsequent deformity improved by later plastic operations.	3rd	—
E. Indian	E. & S.	20 c.c., oedema: general condition rapidly improved.	4th	—
Camel hair E. Indian Alpaca	S.	40 c.c., patient in a state of collapse when serum injected, died 6 hours later.	4th	—
Persian	S.	40 c.c., oedema diminished in 24 hours, discharged 5th day after injection of serum.	3rd or 4th	—
Russian camel, E. Indian goat, Turkey & Cape Mohair	E. & S.	3 injections of 10 c.c.	—	—
Van, Turkey & Cape Mohair, English & Colonial	S.	30 c.c.	—	—
China	E. & S.	10 c.c. subcut. and intravenously, both pustules excised.	—	—

TABLE V (*continued*).

No. of Case	Year	Locality	Sex	Age	Industry	Occupation	F = Fatal	Rm = Recovery slight	Rs = Recovery severe	Nature of Anthrax and situation of pustule	Verification
45	1906	Wellingboro'	M	21	Brush-making	Pan hand	F	—	—	Lower maxilla, much oedema	Microscope
46	,,	Long Melford	M	17	Horsehair manuf.	Hackler and opener of bales prior to disinfection	—	Rm	—	Neck (fever)	,,
47	,,	Liverpool	M	49	Hides Stevedoring	Dock labourer	—	—	Rs	Neck	,,
48	,,	London	M	27	Hides Wharfinger	Labourer handling hides	—	—	Rs	Forehead, glands affected	Anthrax Bac. not found
49	,,	Liskeard	M	21	Tanning	Dressing carcase of animal dead from Anthrax	—	Rm	—	Beneath chin, size of a 5/- piece	Microscope
50	,,	London	M	31	Hides Docks	Loading hides	—	—	Rs	Nape of neck	Culture, etc.
51	,,	,,	M	—	Hides	Furrier (occupier)	—	R?	—	Outer Canthus	,,
52	,,	,,	M	41	Wharfinger	Stevedore	F	—	—	Side of neck, secondary intestinal	,,
53	,,	Liverpool	M	29	Hides Stevedoring	Dock labourer	F	—	—	Shoulder	Microscope
54	,,	Penrhyn	M	38	Bone manure	—	—	Rm	—	Back of neck	—
55	,,	Gomersal	M	17	Blanket & Carpet Yarn	Waste shaker	F	—	—	Neck	Culture
56	,,	Liverpool	M	35	Wool stores (warehouse)	Labourer loading cart	—	Rm	—	Right cheek	Microscope
57	,,	Bingley	M	17	Mohair spinning	Noil picker	—	Rm	—	,,	,,
58	,,	,,	M	58	Wool combing	Wool washer	F	—	—	Left wrist, secondary intest.	Culture, etc.
59	,,	Kidderminster	M	16	Carpets, etc.	Spinner in carpet factory	—	Rm	—	Arm and foot, 2 pustules	Culture
60	,,	Bradford	M	25	Wool combing	Willeying & card jobbing	—	Rm	—	Right cheek	Microscope
61	,,	Dewsbury	F	32	Blankets and rugs	Weaver	—	Rm	—	Left eyebrow, oedema of face	,,
62	,,	Saville Town	M	23	Yarn and spinners	Willeyer	—	—	Rs	Upper eyelid, much oedema, severe case	Culture, etc.
63	,,	Bradford	F	26	Wool combing	Finisher	—	—	Rs	Left side of neck	Microscope, Anthrax Bac. found in pustule but not in blood
64	,,	Queensbury	F	17	Spinners of Alpaca & Mohair	Spinner	F	—	—	Chin, much oedema of neck	Microscope
65	,,	Bradford	M	42	Wool combing	Wool puller and runner	F	—	—	Internal pulm., pleural & pericardial effusions	Culture, etc.
66	,,	,,	M	53	,,	Finishing Box minder	—	—	Rs	Internal (double pleural eff.)	Not verified bacteriologically

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TABLE V (*continued*).

Possible source of infecting material	Treatment E. = Excision S. = Serum	Remarks. Particulars as to Serum, etc. (Serum injected subcutaneously unless otherwise stated)	Probable stage in days when case came under treatment	Various
China & Siberian bristles	E. & S.	10 c.c., temp. was 103·4° F., pulse 120. General appearance bad, face dusky when first seen.	—	—
China & Siberian	S.	—	—	—
Dry Arabian hides	E. & S.	60 c.c.	—	—
China & Thibet	S.	—	—	—
Carcase of horse dead from Anthrax	E. & S. carbolic	General condition bad when first seen, 8 hours interval after excision and injection of carbolic before serum injected, 12 hours after injection of serum great improvement.	—	—
Buffalo hides from Penang	E. & S.	—	—	—
Russian wolf	E. & S.	60 c.c.	—	—
?	E. & S.	Death within 24 hours of admission. Stomach and small intestines ulcerated. Serum was only injected when in a state of collapse 14 hours before death.	—	—
Dry Rangoon hides	E. & S.	Fatal within 24 hours of admission.	—	—
Local bones	E. & S.	30 c.c., 24 hrs. after excision and carbolic 5 %, 24 hrs. after injection of serum wound looked healthy.	—	—
E. Indian, Chinese	E. & S.	—	—	—
Goat hair, E. Indian & Persian wools	E. & S.	—	—	—
Mohair	S. inj. of 2½ % carb.	40 c.c.	—	—
All classes of Cape & Turkey	S.	20 c.c. Internal changes practically confined to bowels. Probably therefore swallowed some Anthrax spores.	—	—
Persian	E. & S.	—	—	—
Persian camel	E. & S.	40 c.c.	—	—
E. Indian, Bradford waste	S.	40 c.c.	—	—
E. Indian, Scotch & native	S. inj. of carbolic	190 c.c. at intervals.	—	—
Van Mohair	E. & S.	40 c.c.	—	—
Turkey & Cape Mohair	E. & S.	2 injections of 40 and 80 c.c., fatal within 24 hours of admission.	—	—
Persian & Turkey Mohair	S.	40 c.c. repeated 3 times, improvement after the first 3 doses, then a sudden collapse.	—	—
Persian	S.	200 c.c.	—	—

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TABLE V (*continued*).

No. of Case	Year	Locality	Sex	Age	Industry	Occupation	F=Fatal	Rm=Recovery slight	Rs=Recovery severe	Nature of Anthrax and situation of pustule	Verification
67	1906	Bradford	M	49	Wool combing	Card minder	F	—	—	Internal (pulm.)	Culture
68	,,	Kidderminster	F	26	Worsted spinning	Comb minder	—	—	Rs	Left side of face	Culture, etc.
69	1907	Liverpool	M	54	Hides and skins	Dock labourer	F	—	—	Neck	Microscope
70	,,	,,	M	35	,,	,,	—	R	—	Right eye	Culture, etc.
71	,,	Frome	M	48	,,	Lime pit foreman	—	R	—	—	—
72	,,	Liverpool	M	32	,,	Dock labourer	—	R	—	Neck	—
73	,,	S. London	M	27	,,	,,	—	R	—	Left side of neck	—
74	,,	E. London	M	40	Wool	Wheeling bales of wool in trucks	—	—	R	Cheek	Culture, etc.
75	,,	Earlsheaton	F	23	Blanket factory	Scribbler feeder	—	—	R	Forehead	,,
76	,,	Ravensthorpe	F	14	Wool	Yarn hank winder	—	—	R	Forearm	,,
77	,,	Bradford	M	48	,,	Wool washer	F	—	—	Left wrist	—
78	,,	,,	M	31	,,	Combwinder	—	—	R	Right arm	Microscope
79	,,	Kidderminster	F	17	,,	Finisher in spinning department	—	—	Rs	Right cheek bone	,,
80	,,	Bradford	M	56	,,	Warehouse-man	F	—	—	Left eye	Culture, etc.
81	,,	,,	M	23	,,	Card grinding	—	—	R	Ear	,,
82	,,	Liverpool	M	41	,,	Tearing can-vas covers of bales of wool	—	—	R	Cheek	,,
83	,,	Kidderminster	F	26	,,	Wool spinner	—	—	R	Eyelid	Microscope
84	,,	Liverpool	M	39	Wool warehouse	Dock labourer	—	—	R	Left cheek	—
85	,,	Kidderminster	F	22	Wool	Card feeder	—	—	R	Hand	Culture, etc.
86	,,	Liverpool	F	19	Horsehair	Carrier	—	—	R	Left side of face below ear	—
87	,,	London	M	44	,,	Drawer	—	—	R	Neck	Culture, etc.
88	,,	Liverpool	F	53	,,	Forewoman hair sorting	F	—	—	Upper lip	Microscope
89	,,	,,	M	46	,,	Drawer & wet hackler	—	—	R	Left cheek	,,
90	,,	Folkestone	M	53	,,	Plasterer	—	—	R	Right eyebrow	,,
91	,,	N. London	F	?	,,	Niece of worker in horsehair	—	—	R	Neck	Culture, etc.

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TABLE V (*continued*).

Possible source of infecting material	Treatment E. = Excision S. = Serum	Remarks. Particulars as to Serum, etc. (Serum injected subcutaneously unless otherwise stated)	Probable stage in days when case came under treatment	Various
?ersian sample oved to contain Anthrax spores	S.	Injections of 40 c.c. subcut. and 50 c.c. intraven. and 40 c.c. subcut. Influenza bronchitic type, no reaction to serum.	—	Death after 60 hours of treatment.
Persian	E. & S.	2 of 40 c.c. Rapid improvements.	—	—
Chinese hides	E. & S.	—	—	—
,,	E. & S.	—	—	—
ıdian, Morocco, Algiers	Cautery, carb. ac., serum	—	—	—
et Italian hides	S.	—	—	—
]lk hides from Bangkok	E. & S.	—	—	—
Colonial	E. & S.	—	—	—
arious foreign wools from Europe & Asia	E. & S.	40 c.c.	—	—
Indian goat, British cow	E. & S.	—	—	—
ıssian & E. In- an hair, camel, goat & lamb	E. & S.	100 c.c.	—	—
Australasian	E. & S.	—	—	—
Persian	S.	Great oedema. Constitutional symptoms subsiding after injection of serum.	—	—
]ape & Turkey Mohair	S.	Death attributed to pneumonia accompanied by local Anthrax.	—	—
Persian	E. & S.	—	—	—
]. Indian wool ınd goat hair	E. & S.	2 injections of 20 c.c.	—	—
E. Indian and English	S.	—	—	—
]. Indian wool ınd goat hair	E. & S.	—	—	—
Indian, Colonial	E. & S.	40 c.c.	—	—
ɔbably Russian hair	E. & S.	—	—	—
Siberian hair	S.	40 c.c.	—	—
Russian hair	E. & S.	Case not diagnosed at first, as symptoms not typical.	—	—
,,	E. & S.	—	—	—
origin of hair	S. & carb. ac. 10 %	—	—	—
—	E. & S.	Patient's neck accidentally scratched by her uncle's finger.	—	—

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SUMMARY.

The result of bacteriological research indicates that the material infected is probably not large compared to the total amount used, and that in suspected samples of both hair and bristles anthrax bacilli can be isolated either by inoculation of animals or by plate cultivation.

Difficulties are met with in the inoculation of animals owing to the presence of the bacillus of malignant oedema, which, unless special methods are used as shown by Duncan, will often mask the presence of the anthrax bacillus altogether.

In separation by means of agar plates the presence of bacilli very closely resembling anthrax again leads to error. Three types of these bacilli have been met with in hair and bristles; viz.: Bac. A^2 or *Bac. anthracoides* of Bainbridge, possibly the same as *Bac. subtilis*, the Bac. A^1, and Bac. A. The last two do not exactly correspond with any known bacilli, and so far as we know at present are of little importance, but in view of the experiments of Gilruth showing that guinea-pigs, rabbits, and sheep can resist the inoculation of large doses of virulent anthrax bacilli completely, provided these organisms are mixed with a larger quantity of some other organisms which are non-pathogenic to these animals, and that a small amount of immunity to pure anthrax is conferred, it is certain that the presence of these anthrax-like bacilli, evidently closely related to the anthrax bacillus, cannot but be of benefit; and it is possible that further experiments may show that injections of them mixed with cultures of anthrax bacilli of varied virulence may confer a higher degree of immunity than do mixtures of anthrax with other non-pathogenic bacilli, as shown by Gilruth (1904).

Webb has observed during experiments in disinfection with cyllin that there was an apparent decrease of anthrax bacilli while the bacillus of malignant oedema increased; which suggested to him that the two are antagonistic. If this is so, is it possible to eliminate the anthrax bacillus from horsehair by increasing the quantity of an antagonistic bacillus, whether that of malignant oedema or other?

The fact that practically all bristles and horsehair on arrival in this country are centred for a time in two or three London warehouses raises the question whether it would not be possible to disinfect the material before distribution. Were disinfection thus centralized it would be a comparatively simple matter to protect the limited number of people exposed to risk in cutting the knots of the bundles and

spreading the horsehair out for disinfection; then the necessity for formal regulations in horsehair and brushmaking factories and workshops in a great measure would be obviated. The manufacturers would gain in being freed from risk of anthrax among their employees and, further, would be able to use hair that many of them have preferred to discard on account of its dangerous properties.

The risk of infection from bristles is so small and the difficulty of disinfection so great on account of its bundled condition that with our present knowledge central disinfection for this class of material cannot be recommended, especially as by such simple devices as the use of small quantities of paraffin this small risk may be still further diminished.

In the case of horsehair it would be necessary, if steam were the disinfectant, to separate the white from the dark hair prior to disinfection. There would be very considerable objection on the part of the trade to central disinfection of horsehair because of the increased cost; many of the manufacturers have already gone to the expense of erecting their own disinfecting plant; moreover, by most disinfecting processes hair is so easily damaged.

From what has been written about disinfection it is evident that at present there is no method of destroying with absolute certainty spores of anthrax in horsehair and bristles, but by the use of steam under slight pressure the risk to the human subject arising during the various manipulations may be diminished very considerably. It has been suggested by Duncan that exposure of infected material to a temperature of about 98° F. for a short time would favour the development of spores of anthrax into bacilli, which then might be easily destroyed by a further short exposure to steam under pressure. This practically amounts to intermittent sterilization. Experiments already described indicate that most if not all the anthrax bacilli were destroyed by this method, but that the bristles were not rendered absolutely sterile; the spores of anthrax, being laboratory specimens artificially placed on bristles, were more easily destroyed than those under natural conditions would have been. It is therefore probable that, as the medium is unsuitable, development of anthrax spores would not take place, and that intermittent sterilization would not be absolutely effective; moreover the exposure of the material to damp steam at normal pressure or steam of any sort for more than half an hour on one occasion damages the hair considerably. That steam is ever likely to be made more effective than at present is improbable, since the dampness of steam at

low pressure damages the hair, but is more likely to effectually destroy the spores, while the drier the steam, the more damage to the hair, but the more likely are the anthrax spores to be destroyed. More hope in the future lies in the use of liquid disinfectants; while none of these up to the present has been found certainly efficacious, cyllin in a strength not exceeding 1 part in 100 of water and at a temperature below 50° C. (122° F.) does not damage hair. Eurich speaks favourably of formalin solution and Leach's fluid in the disinfection of woollen bales.

The possibility of placing a check on the importation of infected raw materials must be considered. In Italy certificates of origin have been found of very little service. The Foreign Office might possibly issue a list of regulations and instructions which, if they could be efficiently enforced, would prevent the goods from entering this country. The objection of increased cost at once arises if, for example, a further dressing, sorting and bundling of the dangerous mane hair from China were required so that it should enter this country half prepared, as do bristles; on the whole it is improbable that measures on these lines would be very effective.

With regard to the measures introduced in Germany a few years ago, and quite recently in England, more stress might be laid on the necessity of washing, use of nail brush, keeping the nails short; in washing the use of an efficient disinfectant is advisable; for this purpose cyllin does admirably, being compatible with soap. Experience shows that soap and water are the true safeguards after handling infected material, and those who use the same stuff after disinfection should wash hands, face, and neck before going home to a meal. By these means, too, the likelihood of workers carrying infection outside would be diminished. The ignorance and carelessness of the workers are undoubted factors in the spread of anthrax. The use of overalls and gloves, though unpleasant and disliked by the work-people, yet is very necessary as cases quoted show.

The regulation by the Home Office requiring the employer to exclude persons suffering from cuts and scratches is, to all intents and purposes, a dead letter. It is impossible to carry out. Anthrax seldom has begun from a recognised scratch or cut; almost every case has undoubtedly arisen from scratching with the nails, where there has been no previous cut but some irritation either by dust or by some insect.

Recent decisions show that anthrax is classed as an accident coming within the scope of the Workmen's Compensation Act.

Facilities for bacteriological examination given by the Home Office since 1899 for verification of doubtful cases might with advantage be extended to examination of suspected samples of hair, etc.

It would be advisable to require the Registrar to communicate with the Coroner in all fatal cases of anthrax.

When possible, walls and pavements of Factories and Workshops should be painted or glazed so as to be easy to clean and disinfect.

In the treatment of human anthrax a great advance has been made by the introduction of Sclavo's serum. It has been pointed out that at present in this country the serum has not achieved the success that it undoubtedly has in Italy, but that there are several reasons which will account for this, the chief being too late administration, and in too small doses. Therefore the necessity for an early diagnosis in all cases is apparent. Early diagnosis of anthrax being difficult, it is essential for a medical man to be attached to each factory, or group of factories, to whom all cases may be referred so that in making a diagnosis the nature of the employment may be taken into consideration: by this timely vigilance remedies, harmless in any case, may be used with far greater prospect of success.

The duties of certifying factory surgeons might be extended with advantage to include the above work, and that there may be no delay they should be supplied with serum by the Home Office. The surgeons should collect samples of suspected material for bacteriological examination, should undertake the entire treatment of all cases of anthrax, and, in conjunction with the local Factory Inspector, conduct an enquiry into the source of infection.

Employees absent from work should report to the employer the cause, and in the case of illness of any kind the employee should be visited at once by the certifying factory surgeon.

The employer should exclude as far as possible work-people with cuts or abrasions unless suitably covered, and for the carrying out of all regulations each factory and workshop should be supplied with, or compelled to supply, means for dressing small cuts, etc.

All cases of human anthrax whether industrial or agricultural should be notified. Both human and animal cases of anthrax should be notified to one authority, or to both the Board of Agriculture and the Home Office, so that if thought advisable the enquiry may be made in common.

Human anthrax being so closely associated with animal anthrax more systematic efforts should be made (1) by limiting the spread of the

disease in nature, and (2) by the immunisation of animals against anthrax, to exterminate the disease among animals.

As to the first, the *Bacillus anthracis* rarely if ever forms spores in the body, and consequently, if the bacilli can be confined to the blood and tissues of carcases of animals that have died from anthrax, in the course of putrefaction the anthrax bacilli die out very rapidly. Unfortunately before death the animal by its discharges sheds into the air myriads of bacilli, which rapidly spore and, given suitable conditions of temperature and soil, germinate, multiply, and spore again; hence it is necessary to dispose of the carcase without shedding of blood, so that no part may be used, either (1) by burning, or (2) by deep burial preferably in quicklime; these methods are equally effective, but perhaps for smaller carcases burning is to be recommended, and for larger ones deep burial. All places likely to have been contaminated with any discharges should be thoroughly disinfected, as with 1 in 1,000 corrosive sublimate.

Regulations exist in most European countries as to disposal of carcases of animals that have died of anthrax, but there is some reason for believing that these regulations are not properly enforced in a great number of districts abroad.

Immunisation of animals against anthrax by injection of attenuated bacilli has been largely carried out. In France by Pasteur's method the loss of sheep from anthrax is said to have fallen from 10 to 1 per cent.; and of oxen and cows from 5 to ·33 per cent. Yet it is stated the figures are fallacious, many of the animals vaccinated not being exposed to infection; and official returns by Cope indicate that the mortality remains as high as ever; further, while Pasteur's first vaccine is mild and harmless yet the second vaccine is dangerous and often fatal, sheep being more liable than cattle; besides, the animals still contract anthrax through the intestines, the common mode of infection, and the time of so-called immunity is not known.

Since Pasteur's experiments the most successful attempts have been made by Sclavo (1903) and Sobernheim (1904).

Sclavo (1903) injected into asses attenuated cultures of anthrax bacilli first, followed by virulent ones, until a high degree of immunity was obtained. The serum of the ass so immunised was found to have strongly protective and curative properties, and, as has been shown, is largely used in cases of human anthrax.

Sobernheim independently elaborated an almost identical serum which is largely used for the protective inoculation of cattle. The serum

is injected into one side of the neck or thigh, and the culture, Pasteur's Deuxième Vaccine (continued growth of anthrax bacilli for 12 days at 42 to 43° C.) into the other side. This method is now widely used in Germany and Brazil and it is said with good results.

Investigations should be undertaken in each country or by some international organisation, to determine accurately the nature and extent of anthrax districts, which should be then kept under supervision and, where possible, drained or rendered innocuous by other means. Such measures would result in a considerable reduction in anthrax among animals and consequently among human beings. Such an organisation would give warning of the prevalence of anthrax in these districts, so that export of infected material might be controlled.

Refuse from factories where raw animal materials are used, certain manures, and imported food stuffs all form a frequent source of infection to animals and indirectly therefore to man.

Dust from horsehair factories is not infrequently sold to manure manufacturers, who after mixing with other ingredients sell it for spreading upon the soil. The profit in the case of one horsehair firm amounted to £150 per annum, so that manufacturers are not likely to forego such profits except under compulsion. Hence it is necessary to prevent the sale of dust arising in the manipulations of dangerous or non-disinfected raw animal products and to do this separate tables and rooms should be used for such material. Such dust should be burnt. The effluent from wool, hair, and skin factories should be rendered inert by some reliable process, such as prolonged boiling, before being discharged, or treated by a suitable strength of some such disinfectant as cyllin.

That imported food stuffs are also a source of infection is illustrated by the case of a man selling, and in part grinding, cake and fodder imported from Prussia and North Russia who developed anthrax.

Where practicable the subjection of the constituents of the various cakes, when in the moist or semi-liquid state, to a temperature of 212° F. for 5 minutes would remove much of the danger from this source. Indian or other meals containing anthrax spores in a dry state would require a much higher temperature to render them safe.

Other general measures as notification of all cases of deaths of animals from any acute disease and of those rendering necessary slaughter on the farm are desirable. A fee should be paid for notification and compensation for animals slaughtered, while failure to comply with these regulations should be punishable by a heavy penalty.

Animals, except in emergencies, should not be slaughtered or their carcases disposed of except on licensed and inspected premises; and, in all cases of animals slaughtered otherwise than by butchers in the ordinary course of their business, a veterinary should inspect the carcase, and give a certificate of the cause of death or disease, stating the uses to which the carcase may be put. A copy of the certificate to be forwarded to the Board of Agriculture as well as to the Medical Officer of Health.

Information should be furnished to Factory and Market Officials; no butcher or knacker should purchase the carcase without having seen the certificate.

Conclusions.

1. Among workers in horsehair and bristles in this country, malignant pustule is by far the most common form of anthrax; other forms occur occasionally.

2. Anthrax in the human subject, whether of industrial or agricultural origin, is derived entirely from animals affected with the same disease. The prevalence of human industrial anthrax varies with the greater or less quantity of material from infected districts which is used. This depends on the state of trade, while the prevalence of agricultural anthrax varies directly with the amount of animal anthrax.

3. The percentage of fatal cases among bristle and horsehair workers is slightly less than that in any other industry, and compares favourably with mortality from anthrax in similar industries in France and Germany; of these workers the disease is more fatal to women than to men.

4. In this country industrial anthrax is somewhat more common than that arising from agricultural pursuits, 55 % of deaths arising under industrial conditions, and 12 % of deaths arising in manipulation of horsehair and bristles.

5. Anthrax forms a professional risk to horsehair workers of ·296 % and to brushmakers of ·029 %. These figures compare favourably with those of similar industries in France and Germany.

6. In horsehair manipulations the risk to male workers is five times as great as the risk to female workers. In brushmaking the risk to males is twice that to females.

7. The risk of infection from horsehair is more that eight times that from bristles.

8. Bristles are not so apt to give rise to infection as horsehair because they are in a further state of preparation and have passed through more hands before importation. For the same reason tail hair is less likely to give rise to infection than mane hair.

9. Infection may arise in any of the horsehair processes, but is more common in the earlier ones and in the manipulation of short hair.

10. There is some small risk of infection from all kinds of bristles and horsehair, including English horsehair; but by far the most risk attaches to Chinese, Russian and Siberian horsehair. The risk of infection from bristle riflings is not great, as probably little of the dirt is animal in origin.

11. Malignant pustule is most common on the exposed and least frequently washed parts of the body, as the face and neck. The nails which harbour dust containing spores are a chief source of infection.

12. The mortality varies with the position of the pustule owing to the difficulty of diagnosis and treatment in certain parts.

13. Infection is not infrequent by conveyance of spores in clothes, finger nails etc. to non-workers.

14. Anthrax is endemic among animals all over the world. It is more prevalent in most countries in the hot summer months and in certain places.

15. The amount of actually infected material imported into this country is probably not large compared with the total bulk.

16. There are present both in bristles and horsehair three types of bacilli very closely resembling the anthrax bacillus but no one of them is pathogenic. The bacillus of malignant oedema is also commonly present.

17. Anthrax in the human subject being derived entirely from animals, it follows that to dispose of the disease from man, it is necessary to make greater efforts to do away with the disease among animals on the lines indicated.

18. Central disinfection is possible in the case of horsehair, but it would probably meet with much opposition from the trade and is not to be recommended.

19. Steam disinfection if carefully carried out, the steam not being so damp as to injure the material, or too dry to be efficacious as a germicide, or at a pressure not above 4 or 5 lbs. to the sq. inch, greatly diminishes the risk, but is not certainly effective in destroying all spores.

20. Immersion of raw material in liquid disinfectants is at present the best method of disinfection. Cyllin (1 in 100) at a temperature not higher than 120° F. is the most suitable though not absolutely effective. The gumming of the hair together is said to be obviated by the addition of a little alkali.

21. An extension of the duties of certifying factory surgeons is advisable, so that early and efficient treatment may be undertaken which is the only method of reducing the mortality.

22. In malignant pustules use of the cautery and subcutaneous injection of serum is advisable in all cases. In internal anthrax injection into the veins is necessary at the earliest moment.

23. Of other regulations the use of washing with nail brush in soap and water with the addition of cyllin or other suitable disinfectant, use of overalls, gloves and respirators etc., are very important.

It is of the utmost importance that every effort should be made to abate or abolish the ravages of anthrax because of its insidious nature, its fatal character, and its widespread occurrence.