was a very small amount of exudate in many of the air cells. The latter changes were, I think, due to the bacilli injected, but nothing like a true glanders tubercle was found.

I had intended to illustrate this paper with micro-photographs, but regret that the latter arrived too late for publication. I may, however, be able to insert them in a future paper.

QUARTER-EVIL, OR BLACK-QUARTER.

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Definition.—The disease which is commonly called quarter-evil or black-quarter in England, and black-leg in Scotland, is a bacterial affection, caused by a specific micro-organism—the bacillus of quarter-evil. In France the disease is generally known by the term symptomatic anthrax (*charbon symptomatique*), originally suggested by Chabert (1782) for those cases of disease in which after a period of fever and systemic disturbance an inflammatory tumour makes its appearance in some part of the body. This author believed that quarter-evil and anthrax were merely symptomatic varieties of the same disease, and he proposed to apply the term *fièvre charbonneuse* to those instances in which the disease ran its course without the development of any tumour. Chabert is generally credited by French authors with having effected a great improvement in nomenclature when he introduced these terms, and with having thereby differentiated from charbon various other affections, such as "putrid and gangrenous fever." It is, however, difficult to understand what were the precise diseases other than anthrax and quarter-evil to which the term charbon was applied prior to the date of Chabert's monograph, and it is obvious that Chabert's definitions left it possible to confound with anthrax several other different diseases, and tended to confirm the opinion, then widely held, that anthrax and quarter-evil were not etiologically distinct.

In this country, long before the discovery of their respective organisms, anthrax and quarter-evil were recognised as things so different as to merit different names, and such confusion as exists at the present time is almost entirely ascribable to the adoption of the French nomenclature by some modern authors. The retention in France of the names proposed by Chabert may be defended on the ground that they are established by long custom, but nothing whatever can be said in favour of displacing the name quarter-evil by symptomatic anthrax. As will be shown in the course of this article, the diseases anthrax and quarter-evil have scarcely a feature in common, and in face of this fact one cannot help being struck with the curious perversity of reasoning which led the older veterinary authors to regard them as manifestations of the same morbid condition.

Discovery of the Bacillus of Quarter-evil.—Feser and Böllinger (in 1876) appear to have been the first to note the presence of rod-like motile bacteria in the lesions of quarter-evil. Both of these authors regarded these organisms as the cause of the disease, and both claimed

to have communicated the disease to cattle and sheep by inoculation. A few years later (1879 and 1880) MM. Arloing, Cornevin, and Thomas published the results of their observations and experiments, establishing the non-identity of anthrax and quarter-evil, and they described the characters of the organism encountered in the lesions of the latter disease. The last-named authors also claimed to have cultivated the organism artificially.

Morphology of the Bacillus.—The organism of quarter-evil belongs to the class of bacilli, though in some of its phases it is less distinctly and regularly rod-shaped than the causal germ of anthrax. As it is found in the tissues of the emphysematous swelling which is characteristic of the disease, it presents a certain variability in size and outline. A number of the rods—generally a minority when the examination is made some hours after death—are cylindrical, with round or slightly tapering ends, and these generally stain uniformly throughout with aqueous solution of methylene blue or other basic aniline dye. These rods are appreciably smaller, both in length and breadth, than the bacilli of anthrax, most of them being about 3-4 μ long (Plate II., Figs. 1, 2, and 3). This type of rod represents the young actively growing and multiplying organism. It is usually outnumbered by bacilli which have the form of a thin spindle, whose ends may be either symmetrical or dissimilar. The substance of the rods of this form usually stains rather faintly with aqueous methylene blue, except at one of its extremities, where there is frequently an intensely stained speck. Finally a certain number of the organisms are distinctly oval or lemon-shaped, and all gradations between these and the elongated spindle form may be found. These departures from a cylindrical form appear to represent a stage preparatory to sporulation. The organism of quarter-evil does not form leptothrix filaments in the tissues, and it is rare to find more than three rods end to end. The bacilli are actively motile when first removed from the lesions, but their movements become slow and finally cease on exposure to the atmospheric air.

The organism of quarter-evil posesses the power of sporulation, and the spores may be formed in the tissues during life, and are constantly found there after the death of the animal. In this respect the organisms of quarter-evil and anthrax are in sharp contrast.[1] The spore commonly develops at one of the poles in the case of the distinctly rod-shaped forms, but frequently its position is central. The fully developed spore is oval, with a greater disparity between its two principal diameters than in the case of the anthrax spore. It is also decidedly broader than the bacillus in which it arises, and hence when the position of the spore is terminal it gives to the rod a shape like a tennis racket (Plate II., Fig. 4).

Cultivation.—The bacillus of quarter-evil is a very strict anærobe. Arloing, Cornevin, and Thomas claimed to have obtained cultures in bouillon made from the flesh of the fowl, and containing small quantities of glycerine and sulphate of iron. The flasks were exhausted of air, and the cultures were carried on for twelve generations. The description given by these authors, however, leaves room for grave doubts as to whether the cultures were

[1] It has been asserted that spores are not formed until after death, but the writer has repeatedly observed sporulation in preparations made from guinea-pigs just dead from the disease.

pure, and the first successful attempts to cultivate the quarter-evil bacillus in a state of undoubted purity were made by Kitasato.[1]

The most favourable temperature for growth is from 36-38° C. No growth takes place at temperatures below 14° C., and only a sparing slow growth at 16-18°. Sporulation takes place rapidly in artificial cultures at the body temperature, and slowly at summer temperatures. The characters of the growth in different media are thus given by Kitasato.

In bouillon, in an atmosphere of hydrogen, the organism grows rapidly at the body temperature, and soon produces a general turbidity of the liquid. A little later small flocculi appear throughout the entire liquid, and these gradually settle to the bottom as a whitish precipitate, leaving the liquid clear. Gas is evolved and gives rise to a fine foam at the top of the liquid close to the wall of the flask or tube. The cultures exhale a sour odour, recalling that of rancid butter.

Cultures may be obtained in solid gelatine or agar by adding to these media while liquid 1·5-2 per cent. grape sugar, 4-5 per cent. glycerine, ·5-1 per cent. formiate of soda, or ·1-·3 per cent. of sulphindigotate of soda, to absorb all traces of oxygen. Single colonies in gelatine grow at first as irregular round balls with a slightly rough surface. The surrounding gelatine is liquefied, and radiating threads then grow out from the central mass into the liquid gelatine. In gelatine stab cultures the growth begins one or two finger-breadths below the surface, and the gelatine is slowly liquefied with evolution of gas bubbles. In agar also gas is evolved and leads to disruption of the medium. In these artificial cultures the organism presents the same forms as in the diseased tissues.

Staining.—The bacillus of quarter-evil in cover-glass preparations from the diseased tissues stains readily with any of the dyes in common use. The most characteristic picture is obtained by staining such a preparation with simple aqueous solution of methylene-blue. The bacilli take the stain instantly, and the preparation should be washed with water only, and then dried preparatory to mounting in Canada balsam. The organism is not stainable by the method of Gram. As in the case of the anthrax organisms, the spores remain unstained by the ordinary methods, but they may be coloured by exposing them to super-heated carbol-fuchsin solution in the autoclave (120° C.).

Distribution of the Bacilli within the Body.—The bacillus of quarter-evil is mainly a tissue parasite. The only place in which it is constantly found in natural cases of the disease is the emphysematous muscle tumour and its immediate neighbourhood. Here the bacillus is found in large numbers in the connective tissue of the muscle, and in the substance of the muscular fibres. The best preparations are obtained by smearing a cover-glass with a minute fragment torn from the discoloured muscle. When exudates are present in the pleural or peritoneal cavities the bacilli are present in the liquid. On the other hand the blood, the spleen, and all the internal organs, when examined immediately after death, may appear free from bacilli. Sometimes, however, the blood everywhere contains a considerable number of bacilli at the time of death. The statement by

[1] Zeitschrift für Hygiene, Bd. vi., p. 103, and Bd. viii., p. 55.

Arloing, Cornevin, and Thomas, that the bile is always rich in the bacilli is erroneous. As a rule the bile shows few or no bacilli, and even 2 cc. of it may fail to inject a guinea-pig. Quarter-evil is thus not a septicæmia, if by that term one understands a disease in which the causal organism propagates mainly in the blood and is found in large numbers there. In black-quarter, as in tetanus and malignant œdema, death usually results from the effects of toxic substances generated by the bacilli in extra-vascular positions and absorbed into the blood.

Resistance of the Virus.—A 5 per cent. solution of carbolic acid in water is fatal to spore-free cultures in three to five minutes, but an exposure of ten hours to the same solution is required to sterilise artificial cultures containing spores. Spores in artificial cultures retain their virulence after being heated for an hour at 80° C., but they are killed in five minutes at 100° C. (Kitasato). A much greater resistance to germicides is exhibited by the spores when these are contained in dried muscular tissues from a black-quarter lesion. The fresh juice or muscle enclosed in a sealed tube is completely sterilised in two hours at 80° C., and in two minutes at the boiling temperature, but if the fresh virulent muscle be quickly dried at 35° C., and subsequently mixed with water, it requires an exposure of two hours at the boiling temperature (100° C.) to completely destroy its virulence (Arloing, Cornevin, and Thomas). The dried and powdered muscle may be steamed at 100° C. for six hours without entailing the destruction of all its contained spores.

Putrefaction apparently has little effect on the virus of black-quarter, at least Arloing, Cornevin, and Thomas found the débris of muscle that had been putrefying for over six months still infective. They assert that their experiments in this direction were never successful with muscle taken thirty months after death, but guard themselves from concluding that buried carcases are always innocuous after that interval.

Habit of Life of the Bacillus.—There seems to be little room for doubt that the bacillus of quarter-evil in certain localities leads a saprophytic existence in the soil, and that, like the tetanus organism, it is only occasionally and, as it were accidentally, parasitic and pathogenic. The markedly regional distribution of the disease is easily explained on this supposition, and opposed to the view that the organism maintains its existence mainly by propagating in the animal body. At the same time, it is obvious that a single case of quarter-evil rapidly brings into existence such a number of the bacilli as are probably never formed within the same compass outside the body, and the burial of the carcase of an animal dead of the disease adds to the soil a colossal number of the germs.

Susceptibility.—The only animal in which quarter-evil appears to occur with frequency is the ox, and indeed the disease is rarely diagnosed in any other species. Nevertheless, the disease is not very rare in the sheep, and animals of that species are much more susceptible to experimental infection by way of inoculation than cattle. In the experience of the writer black-quarter has been the cause of considerable losses among sheep on farms in England and Scotland.

In sheep the susceptibility to quarter-evil persists throughout life,

but in the ox species it appears to diminish in a marked manner after two years of age. The disease is rather uncommon in cattle over that age, and in this country exceedingly rare in adult cattle. Arloing, Cornevin, and Thomas assert that this comparative immunity of adult cattle is met with only in quarter-evil districts, and that full grown animals possess no immunity in places where the disease is unknown among the young cattle. These authors endeavour to explain the alleged fact by supposing that in districts in which the disease is of frequent occurrence many animals suffer from slight attacks, not manifested by any serious symptoms, and thereby acquire immunity. The hypothesis is not very satisfying, and the evidence in support of the assertion that age brings immunity only in black-quarter districts is very slender. In this country it frequently happens that cattle bred and reared on farms free from black-quarter are transported to districts in which the disease is comparatively common, and yet few practitioners have ever seen a case in an adult animal. It is therefore probable that the escape of full-grown animals is due to an immunity which is naturally acquired with age, as is undoubtedly the case in several other bacterial diseases.

It has also been asserted that new-born calves have a considerable degree of immunity, and that this increases during the first few months of extra-uterine life, while the diet is mainly or exclusively milk, but declines when the animal takes to a herbivorous diet. These assertions are also far from being conclusively established by the available evidence, and it is quite as likely that the rarity of cases in very young calves is due to the fact that the nature of their food and the circumstances in which they are usually kept exclude some of the risks of infection. It is quite certain that among animals of other susceptible species there is no immunity during early life.

It was at one time a universally accepted opinion that quarter-evil was mainly a disease of forced or over-fed animals. This opinion has rightly been abandoned, and it is certain that the disease often attacks animals in poor or middling condition. Indeed, practitioners of experience have arrived at the conclusion that on some farms a more liberal system of feeding has reduced the prevalence of the disease.

A few alleged cases of black-quarter in the horse have been recorded, but the observations are not free from doubt. The pig appears to be immune against the disease. Among the smaller laboratory animals the guinea-pig is readily infected by subcutaneous inoculation, but the rabbit has a high degree of immunity. The fowl and the pigeon are also immune. There is abundant experience to warrant the statement that man also is immune.

Symptoms.—There are few diseases in which the clinical picture is more characteristic than in black-quarter. In animals under close observation the first symptom observed is generally lameness or stiffness of gait, and except by those well acquainted with the disease this is apt to be set down to injury. The animal is already dull and the temperature is above the normal. Appetite and rumination are soon suspended, and a swelling appears on the lame limb or some part of the body or neck. At first this swelling may not present any very special characters, but it soon becomes emphysematous and imparts a crackling sensation to the fingers when it is manipulated.

At first the swelling is manifestly painful and sensitive to pressure, but when it has become markedly emphysematous it often appears to be wholly insensitive, and may be cut into with the knife without the animal evincing any pain. Not rarely two or more swellings are formed. The animal becomes more and more dejected in appearance, the breathing accelerated, the pulse frequent. As the end approaches the patient assumes the recumbent posture, the ears and extremities become cold, the internal temperature falls, and death takes place quietly without convulsions. In rare cases the disease runs its course and ends in death without the development of any muscular or subcutaneous lesion discoverable during life. The period of observed illness in fatal cases varies from a few hours to a day, and in exceptional cases extends to two or three days.

The foregoing description applies especially to the disease as it presents itself in cattle. In the sheep the development of the emphysematous tumour is generally masked by the fleece, but the animal is sometimes observed to be lame. It lies persistently if left to itself, has a depressed anxious expression, soon becomes unable to rise, or support itself if placed on its legs, loses consciousness, and dies quietly. The duration of the disease is generally shorter than in cattle, and in many instances the animal is found dead without having been observed to be ill.

The disease is remarkably fatal, and it falls to the lot of very few people to observe recovery after the onset of the more urgent symptoms and the development of the emphysematous tumour. It is asserted, however, that in herds in which the disease frequently occurs, abortive non-fatal attacks are occasionally observed, recovery gradually taking place after the animal has for a few days displayed indefinite symptoms of illness, or even developed a slight swelling in some part of the limbs or body. It is obvious that except in the latter case the diagnosis must be conjectural, but there is nothing inherently improbable in the view that, as in anthrax, many cases of actual infection are not manifested by any pronounced symptom of illness. Systematic employment of the thermometer on all the apparently healthy animals whenever a fatal case occurs in a herd would doubtless throw light on this point.

When recovery does take place in cases in which a distinct tumour has been evolved convalescence is slow, since it involves either the gradual absorption of the necrotic tissues, or detachment of more or less skin and dead muscular tissue as a slough.

Lesions.—When the *post-mortem* examination in cases of black-quarter is delayed for a few hours after death the abdomen is found to be distended with gas, the anus may be everted, and blood-stained froth escapes from the nostrils. In the external appearance of such a carcase there is nothing to distinguish it from a case of anthrax. Rigor mortis sets in very soon after death, and putrefactive changes proceed rapidly. Over the emphysematous tumour in cattle the skin may be dry and parchment-like. In sheep the epidermis over the swollen part is generally partially shed, the wool is easily pulled out, and a sanious thin exudate exudes through the skin.

The blood in black-quarter always forms a good firm clot, this being one of the many striking differences between the disease in question and anthrax. As previously mentioned, the bacilli are frequently

absent from the blood or present in only small numbers, but both in sheep and in cattle they are sometimes present in considerable numbers, and even when the *post-mortem* examination is made within an hour after death the blood in the heart and large vessels may be frothy from the gas evolved by the bacilli. Nevertheless, even in these cases the blood clots firmly.

When the skin is removed from the neighbourhood of the emphysematous tumour the subcutaneous tissue is found to be saturated with a more or less deeply blood-tinged watery exudate. A similar exudate infiltrates the muscular tissue at the circumference of the emphysematous lesion. Within the latter more or less of the muscular and intermuscular tissues are dark in colour from congeston and actual blood extravasation, and the cut surface of the muscle has a characteristic porous appearance, due to the disassociation of its bundles by the gas evolved under the agency of the bacilli. The markedly emphysematous parts are often rather dry, and in contrast to the œdematous condition of the peripheral parts of the lesion. When the autopsy is made soon after death the escaping gas, the inflammatory œdema, and the muscular tissues are entirely free from putrefactive odour. On the other hand, the tissues of the tumour have a very characteristic sour odour, recalling that of slightly rancid butter.

The lymphatic glands in the neighbourhood of the emphysematous tumour are swollen and dark in colour from congestion.

The thoracic and abdominal viscera seldom show any notable alteration of structure, and, in contrast to anthrax, the spleen is nearly always normal in volume and consistence. Moderate quantities of blood-stained watery exudate may be present in the great serous sacs.

Microscopic examination of the muscular tissue from a black-quarter tumour reveals alterations of a comparatively simple character. The most pronounced feature in the lesion is the presence of an exudate or at many places actual blood, between the muscular bundles and in their interior. Numerous hæmorrhages have disassociated the muscular fibres and torn them across (Plate II., Figs. 5 and 6). The fibres involved in these hæmorrhages have for the most part lost their transverse striation, and the sarcous substance is more or less degenerated. Fibres not implicated in hæmorrhages may also show degenerative changes, but for the most part these are but little altered in structure, even where they bound the gas-containing spaces. The connective tissue between the bundles of muscular fibres has its lymphatic spaces distended with an exudate which is remarkably poor in leucocytes. Indeed, the almost entire absence of leucocytary reaction is one of the notable features of the lesion. As previously mentioned, the bacilli are numerously present in the tumour, and they are more abundant between the muscular fibres and in the connective tissue between the fasciculi than in the sarcous substance of the fibres. Few or none are present in the extravasated blood where that has been recently effused.

Method of Infection.—The black-quarter bacillus being in all probability a soil organism in certain districts, it would be natural to suppose that animals are usually infected by ingestion of the bacilli or their spores along with food or water. There is, however,

a great difficulty in accepting this view of infection—viz., the fact that it is difficult or impossible to infect animals experimentally by way of the alimentary canal, even when the individual selected for the experiment is very susceptible and the quantity of virus administered by the mouth enormous. At the date of the first edition of their work on black-quarter, Arloing, Cornevin, and Thomas had had nothing but failures in their attempts to infect in this way; but in the second edition of their work[1] they claim one success. The details of the experiment, however, are in some respects remarkable, and leave considerable room for doubt as to the explanation of the result. A quantity of fresh virus was sealed up in glass tubes, which were exposed for various periods of time to a temperature of 70° C. The virus thus heated for an hour had its virulence scarcely affected, that heated for one hour and thirty-five minutes was to some degree attenuated, and with an exposure of ten minutes longer the virus was so enfeebled that it generally failed to kill. But the same virus heated for two hours at the same temperature had its virulence so exalted that it proved fatal by inoculation to guinea-pigs, and even to the rat, which is immune against the natural virus! Feeling doubtful as to the nature of the disease induced in these circumstances, the authors mentioned administered to a six-months-old calf some pulp prepared from the muscles of a guinea-pig that had succumbed to inoculation with some of the virus heated for two hours at 70°. The calf died six days afterwards from black-quarter, and this is the alleged case of successful infection by ingestion. In view of the uniform failure of numerous other attempts, it appears possible that this was a natural case of black-quarter, and in any case the experiment does not appreciably diminish the difficulty of accepting ingestion as the common method of infection.

The only tolerably certain method of communicating the disease experimentally is subcutaneous or intra-muscular inoculation, and this suggests that a similar method of infection, acting through small wounds about the extremities, may be in operation in natural cases. To some extent opposed to this view is the fact that the lower parts of the limbs are rarely involved in the lesions, but the objection is not insuperable, for the denser connective tissue of the extremities appears to be less favourable than the loose inter-muscular tissue for the development of the bacillus, and the germs which are introduced about the feet may be carried rapidly up the limb in the lymph stream, or gain direct access to the blood-stream, and first excite a lesion when they become arrested and begin to multiply rapidly in some of the muscular masses.

It must be confessed, however, that this part of the subject is involved in uncertainty, and demands further experimentation.

In one instance which came under the notice of the writer, a few sheep were very regularly attacked with black-quarter each time that the flock was gathered together for such purposes as shearing, dipping, etc., whereas few or no cases occurred at other times. The affected sheep were usually noticed to be lame a day or two after such occasions, and on the following day they were usually found dead. In that case probably the sheep were inoculated from soil or dirt in the place where they were penned together.

[1] Pp. 119 and 140.

Diagnosis during Life.—The diagnosis of black-quarter during life is usually an easy task, for mistake is hardly possible after the development of the emphysematous swelling. The painless diffuse subcutaneous emphysema, unassociated with any inflammatory œdema, which occasionally results from the pumping of air into a wound during the movements of the part, cannot be mistaken for the black-quarter tumour, which is circumscribed, involves the deeper tissues, and is associated with an abundant inflammatory œdema at its periphery. Confusion between black-quarter and anthrax is possible when the former disease runs its course without the development of a discoverable tumour. In such a case the age of the animal and the history of the farm with reference to the occurrence of previous cases may serve as guides to a probable diagnosis. Doubt may also exist for a brief period in those rare cases of anthrax in which an inflammatory swelling is formed at some part of the body, but such swellings are easily distinguished from those of black-quarter by the fact that they never become emphysematous.

Diagnosis after Death.—Here there is seldom room for error when the examination is made while the carcase is still fresh. Cases of black-quarter without a distinct emphysematous lesion in some part of the muscular system are very rare, and when such a lesion is present it cannot, with ordinary care, be mistaken for anything else. The association of the emphysema with inflammatory œdema and hæmorrhage, the absence of putrefactive odour, and the sour rancid smell, absolutely distinguish the lesion of black-quarter.

When putrefaction has set in mistakes may be made in two different directions. Putrefactive evolution of gas may, by an inexperienced observer, be mistaken for the emphysema of black-quarter, or advanced putrefactive changes may partially mask a black-quarter lesion. The first of these errors is inexcusable, for, as already stated, the fresh black-quarter lesion has a sour but not a putrid odour. When hypostatic congestion and putrefactive changes have so altered the appearance of the tissues as to make it difficult to distinguish a black-quarter lesion, recourse may be had to inoculation experiments. A piece of the suspected muscle, or the fluid expressed from it, should be injected into the thigh of a guinea-pig, after it has been heated for a few minutes at 70° C., with the object of killing the associated putrefactive bacteria. This method sometimes immediately yields conclusive results, the guinea-pig dying in from twenty-four to forty-eight hours with a non-putrid, sour-smelling, emphysematous lesion at the seat of inoculation. Microscopic examination of a stained cover-glass preparation from the lesion will then show numerous black-quarter bacilli, which may be recognised by the characters already described. In this connection it may be observed that, while the young actively multiplying black-quarter bacilli have no morphological character by which they can be certainly distinguished from some putrefactive bacteria, the picture presented by a methylene-blue preparation from a fresh black-quarter lesion is fairly characteristic, and with a sufficient magnification it may, by anyone with a little experience, be relied upon in making a diagnosis. The guiding features of such a preparation are, the size of the bacteria, and the combination of a few regularly cylindrical bacilli, with less deeply stained spindle-shaped organisms and spore-bearing racket-shaped forms.

Microscopic examination, however, is much less serviceable in black-quarter than in anthrax. It is hardly required when a fresh emphysematous tumour is present, and when such a tumour is not fresh the characteristics of the bacterial picture are lost. In black-quarter microscopic examination of the blood is not reliable if putrefaction has set in, and it is of little service even when the carcase is fresh, since the bacilli are often absent from the blood or present only in small numbers.

Finally, in connection with this part of the subject it ought to be remarked that carelessly conducted *post-mortem* examination of animals dead of black-quarter leads to serious soil contamination, since at the time when the carcase is generally opened the lesions contain enormous numbers of spores, which can with difficulty be destroyed, owing to the extreme resistance that they offer to germicides.

Treatment.—It is doubtful whether any therapeutic treatment is of the slightest avail against black-quarter. No medicinal substance introduced by the mouth can be expected to reach the seat of the disease in such a degree of concentration as will be appreciably hurtful to the bacilli, and the administration of so-called stimulants is of doubtful value in aiding the natural powers of the body to overcome the microbes. Surgical measures are probably just as inefficacious. The deepest scarification possible will hardly ever permit one to bring the remedy into direct contact with more than a small proportion of the organisms, and in the event of the patient surviving the attack its ultimate recovery will be rendered less probable by the putrefactive and pyogenic organisms that are almost certain to gain access to the exposed necrotic tissue.

Prevention.—MM. Arloing, Cornevin, and Thomas believed it possible to confer immunity against the disease by using as the vaccinal matter the fresh virus obtained from a black-quarter tumour. For the purposes of vaccination this material might be introduced in minimal doses into the subcutaneous tissue, or in considerable quantity into a vein or into the trachea.

The first of these methods was found to be unavailable in practice owing to the difficulty of determining for each case, in view of varying susceptibility of the individual and varying strength of the natural virus, the exact quantity necessary to avoid fatal accidents and at the same time provoke a reaction sufficient to leave the animal protected.

In the intravenous method of inoculation two parts of muscular tissue from a black-quarter lesion are triturated with one part of water, the resulting pulp is squeezed, and the liquid obtained is freed of its coarser particles by filtration through muslin, after which it is further diluted by the addition of four times its volume of water. To vaccinate a calf 2 to 3 cc. of this liquid are injected into the jugular vein, which is exposed by dissection in order to avoid the introduction of any of the liquid into the connective tissue intervening between the skin and the wall of the vessel. The authors state that this method of vaccinating is "certain and almost devoid of danger," and they practised it on 500 animals in 1880 and 1881, with only one death as the result of the operation. The method, however, has since been abandoned in favour of vaccination with an attenuated virus.

Intra-tracheal injection of liquid prepared as described above was found to confer protection, but this method was never applied in practice.

In the method of vaccinating which has been most largely put into practice the material employed is muscular tissue from a black-quarter lesion which has first been dried at a low temperature, and then submitted for seven hours to a high temperature in order to diminish its virulence. The preparation of the vaccin is thus described by Arloing, Cornevin, and Thomas. The pulp obtained from a perfectly fresh black-quarter lesion is spread in a thin layer on a plate and dried at 32-35° C. The dessicated material is found to be very virulent, and it retains its strength for a very long period (one or two years). A sufficient quantity of the dried virus is triturated in a mortar with two parts of water so as to form a uniform paste, which is then spread in a thin layer on a plate, and placed in a stove previously raised to a temperature of 100-104° for the first vaccin, and 90-94° for the second. Here the material is left for seven hours, and when taken out of the stove it presents itself under the form of a brownish scale, easily detached from the surface of the vessel containing it. The material may be preserved for a long time in this condition. To prepare it for injection it is ground to a fine powder, and thoroughly mixed in a sterile mortar with water in the proportion of 1 centigramme of the dried virus to half a cubic centimetre of water. The vaccin may be introduced either under the skin of the ear or of the tail, the latter position being the one generally selected. The dose of the liquid, mixed as above, is half a cubic centimetre (= 1 centigramme of the dry powder) for a yearling calf, and a little less for younger animals. The first vaccin is injected near the extremity of the tail, on its under aspect, and the second is introduced a few inches higher up. An interval of about eight days is allowed between the two operations. The method has occasionally been modified to the extent of dispensing with the first vaccin, or operating behind the shoulder instead of at the tail or ear.

Professor Kitt of Munich proposed a modification of Arloing's method which has been practised on a considerable scale. It consists in exposing the dried and powdered virulent muscular tissue for six hours to steam at 100° C. The material thus attenuated is afterwards dried to preserve it. The dose of the dried material is 1 decigramme, and no second vaccination is practised. The method further differs from that of Arloing in that the vaccin is injected into the subcutaneous tissue near the elbow.

More recently Kitt has supplied a vaccin which contains artificially cultivated black-quarter bacilli and their spores. Here again only one operation is practised, and the vaccin is injected near the point of the elbow.

In endeavouring to estimate the economic value of these methods of protective inoculation against black-quarter the two main points for consideration are, (1) the safety of the operation, and (2) the degree of protection conferred by it.

There appears to be abundant material from which one may estimate the degree of risk attending each of the already described

methods of operating. The following table[1] supplies for this purpose most valuable statistics.

Method of Inoculation.	*Number of Animals inoculated.*	*Accidents.*					
		Deaths from inoculation.	*Deaths per thousand.*	*Deaths from natural black-quarter after inoculation.*	*Deaths per cent.*	*Combined losses.*	*Per cent.*
Double operation at the tail .	325,893	188	0·56	1245	0·38	1433	0·44
Total inoculations in the region of the shoulder . . .	91,066	76	0·84	365	0·40	441	0·48
Two operations at the shoulder	37,410	8	0·22	157	0·42	165	0·44
Single operation at the shoulder with Kitt's attenuated muscle powder . . .	39,084	61	1·56	187	0·48	248	0·63
Single operation with Kitt's pure culture . . .	5,643	8	1·41	81	1·43	89	1·58
Total . .	499,096	341	0·68	2035	0·40	2376	0·47

The figures quoted in the table show that in nearly half a million inoculations the average loss from the operation itself was about one animal for each 1470 inoculated, and that it was appreciably greater from the Kitt methods than from Arloing's method of double vaccination at the extremity of the tail. The figures as they stand are very reassuring, but in reality they ought to be read with others which indicate what are the occasional losses among smaller numbers of animals. Unfortunately, these are sometimes considerable, and in the case of single herds may reach to from 2 to 5 per cent.; and this even when the same sample of vaccin has been used in a number of other herds without entailing any accident whatever. In short, the black-quarter vaccin appears to be open to the same objection as the Pasteurian anthrax vaccin, and perhaps even to a greater degree, namely, that human foresight and care cannot provide a material that will have sufficient virulence to confer protection and yet not, for some individual animals, overstep the bounds of safety.[2] There are few diseases in which individual susceptibility appears to be liable to wider variation than in black-quarter, and hence arises a great difficulty in preparing a vaccin of suitable strength for all.

[1] Taken from an article contributed by Herr Strebel to the proceedings of the Sixth International Veterinary Congress, Bern, 1895.

[2] For a singular instance of serious accidents following black-quarter vaccination in Great Britain, the reader is referred to Vol. IV., page 53, of this Journal.

The second point—the degree of immunity conferred by the operation—is no less important than the first. It may be estimated in two ways, viz. (1) by experimentally testing the recently vaccinated animal with a certainly fatal dose of strong virus, and (2) by comparing the death-rate from black-quarter among a large series of vaccinated and unvaccinated animals kept in identical conditions.

The first of these methods is not so serviceable as it might at first sight appear to be. Owing to the very considerable degree of insusceptibility occasionally encountered in unvaccinated animals, such a test is fallacious unless it comprises a number of animals, including some that have not been vaccinated. The test is therefore generally inadmissible on the ground of cost.[1]

Figures given by Strebel permit one to estimate the value of protective inoculation in the second way. That author gives statistics relating to 192,866 inoculated animals and 315,168 uninoculated animals kept together on the same pastures. Of the former 840, or 0·43 per cent., died from naturally contracted black-quarter, while among the latter there were during the same period 5482 victims of the disease (1·74 per cent.). When the deaths from inoculation black-quarter were added, the losses were still three and a half times greater among the unvaccinated than among the vaccinated. If these figures are reliable—and there does not appear to be any reason to doubt them—the black-quarter inoculation must be credited with having saved the lives of a large number of animals in those countries in which it has been extensively practised, and it appears to be worthy of a more extended trial than it has yet received in this country, at least in the case of farms on which the disease frequently occurs, and where, consequently, there is strong inducement to face the risk incidental to the operation itself.

In speaking of these methods of vaccinating animals against black-quarter the dried muscle powder used in the operation is often referred to as an "attenuated" virus, but it is by no means certain that any true attenuation, such as belongs to the Pasteurian anthrax vaccin, has been impressed upon the germs present in the material. During the preliminary drying at 32–35°C. to which the virulent muscle is subjected, the bulk of the bacilli present in it probably resolve themselves into spores, and it is by no means certain that all of these retain their vitality after exposure for seven hours to temperatures of 90° or 100° C. If we assume that a considerable proportion of them are thereby killed, that would explain the apparent attenuation, that is to say, the diminished virulence of a fixed quantity of the dried muscle would be ascribable to the diminished number of living spores in it. Under this view the system of vaccination with dried muscle that has been heated to 90° or 100° C. would be equivalent to inoculation with minimal doses of the fully virulent fresh muscle juice. This view finds support in the fact that when either the first or the second vaccin is used with fatal effect, the bacilli found in the lesions give absolutely no evidence of diminished virulence. Either of the vaccins may be employed with fatal effect: (1) by using larger doses than those prescribed for vaccination, (2) by bruising the tissues at the seat of inoculation, or (3) by adding a small quantity of lactic or

[1] See report of such a test carried out by a Committee of the Midland Veterinary Medical Association, Vol. IV., page 379, of this Journal.

acetic acid to the vaccin before injecting it. The bruising of the tissues and the addition of such agents as those mentioned doubtless act, not by increasing the inherent virulence of the spores in the vaccin, but by diminishing the resistance (phagocytosis) which leucocytes and other cells are able to offer to the multiplication of the germ within the body.

The immunity conferred by vaccination with the heated muscle powder is supposed to last for about a year, but there is little or no reliable evidence on this point. There can be little doubt that the protective effect is strongest a short time after the operation, and then gradually declines, but in cattle this decline is obscured by the relative immunity which is acquired naturally with age.

Setoning, as a preventative of quarter-evil, has long been practised in this country, and many veterinary surgeons and stock-owners still retain faith in its efficacy, but it cannot be said that the evidence in its favour is at all convincing, while there is much evidence pointing the other way. The experience on which a belief in the efficacy of setoning is founded is generally far too narrow to justify a strong conclusion either way. The evidence offered usually is to the effect that fewer cases of black-quarter have occurred on particular farms after setoning than in previous years when the operation was not practised, or that during the same period fewer cases of the disease have occurred on farms where the young cattle had been setoned than on others where they had not been so operated upon. It hardly needs to be pointed out, in view of the erratic distribution of the disease on different farms, and the variable number of cases occurring in different years on the same farms, that evidence of this kind is of little or no value unless it embraces very large numbers of animals. What is required, but is not obtainable, is detailed information regarding the death-rate from black-quarter among setoned and unsetoned animals grazed together or fed together in the same premises.

There is, however, a good deal of clinical evidence standing to the discredit of setoning. In the first place, many veterinary surgeons have found it so inefficacious that they have abandoned it altogether, or practise it only at the urgent solicitation of their clients. And with reference to this point it may be observed that a much narrower clinical experience is required to justify an unbelief in the efficacy of setoning than is necessary to justify faith in it. A setoned animal may escape the disease although it has not acquired any protection from the operation, and hence its escape must not be immediately placed to the credit of setoning. On the other hand, death of a setoned animal from black-quarter is positive evidence that that animal was not protected by the operation, or at least not sufficiently protected to withstand the risk of infection to which it was exposed.

In the second place, such experimental evidence as is available on the point indicates that setoning confers no protection against black-quarter.[1]

Measures of prevention ought to include, but seldom do include, the exercise of proper care in dealing with the carcases of victims of the disease. As previously stated, such a number of black-quarter bacilli as are contained within the carcase of an animal dead of the disease are probably never formed within the same compass outside the animal

[1] See experiments by S. Stockman in this Journal, Vol. X., p. 232.

body, and the burial of such a carcase, or the dissolution of an unburied carcase left where the animal died, adds an enormous number of spores to the ground. Here putrefaction cannot be relied upon to render the carcase innocuous, and it is therefore indicated to bury animals dead of black-quarter deeply in some place to which cattle and sheep will not afterwards have access.

Finally, it may be observed that improvement of the land must apparently be reckoned among the means of preventing black-quarter. Probably the most important of such improvements is draining, but ploughing and crop-growing, as opposed to leaving the land under permanent pasture, may also act beneficially. It is at any rate certain that black-quarter is now an almost unknown disease in many districts where it was at one time very prevalent, and that its decline followed the introduction of better methods of farming.

DESCRIPTION OF PLATE II.

Fig. 1. Black-quarter bacilli (non-sporulating) from a calf (× 750).

Figs. 2 and 3. Ditto (× 1000).

Fig 4. Black-quarter bacilli from a calf (× 750). The great majority of the bacilli are sporulating.

Fig. 5. Section from a black-quarter tumour in a calf (× 60); *a*, muscular fibres involved in a small hæmorrhage; *b*, extravasated blood; *c*, inflammatory exudate.

Fig. 6. Another field in the same preparation as Fig. 5, *a*, *a*, *a*, gas-containing cavities; *b*, connective tissue infiltrated with blood; *c*, muscular fibres.

EDITORIAL ARTICLES.

REPORT OF THE ROYAL COMMISSION ON TUBERCULOSIS

SINCE the date of our last issue the Royal Commission which was appointed in July 1896 to inquire further into the subject of tuberculosis has issued its Report. At a later part of this number we have printed the series of recommendations with which the Report concludes, and we propose here to consider some of these, and the reasons for them which are embodied in the Report.

It may be well to recall the fact that this is the third occasion on which the subject of tuberculosis has been considered by a Departmental Committee or a Royal Commission. In April 1888 a Departmental Committee was appointed to inquire into pleuro-pneumonia and tuberculosis, and it issued its report in the latter part of the same year. In 1890 the first Royal Commission on tuberculosis was appointed "to inquire and report what is the effect, if any, of food derived from tuberculous animals on human health; and if prejudicial, what are the circumstances and conditions with regard to

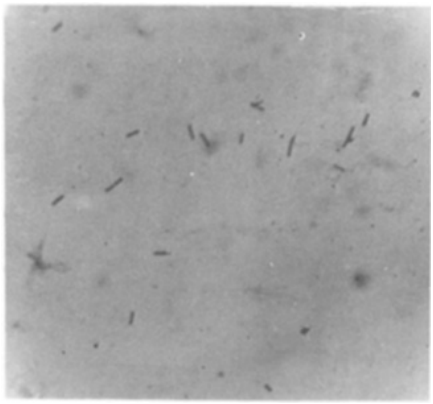

Fig. 1

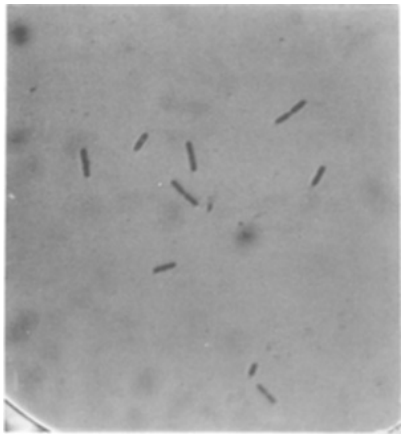

Fig. 2

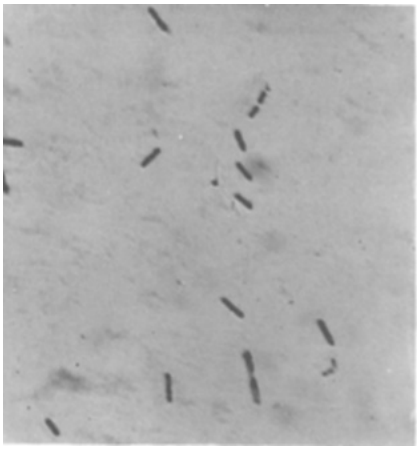

Fig. 3

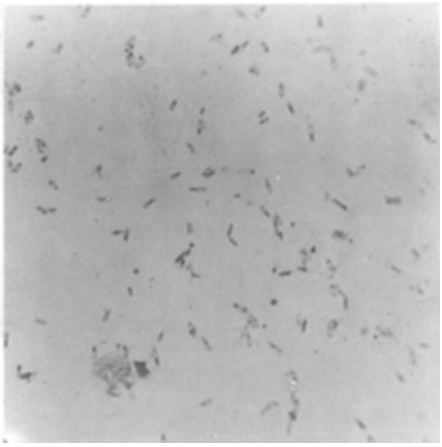

Fig. 4

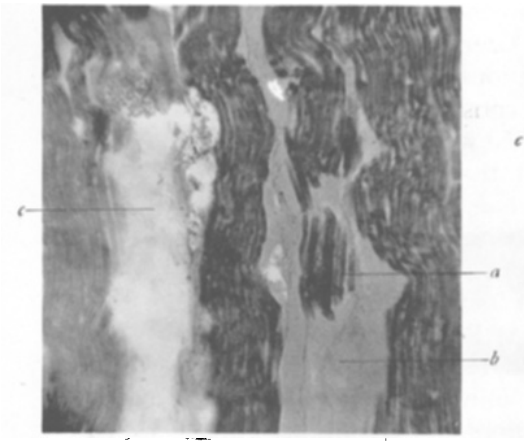

Fig. 5

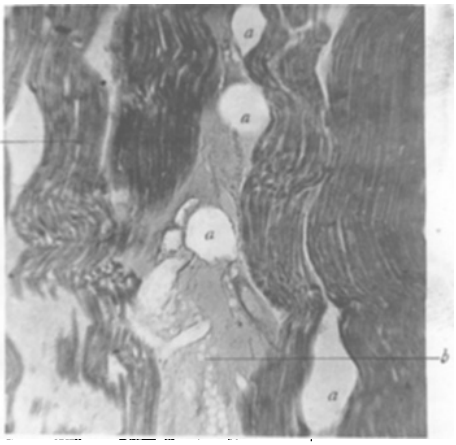

Fig. 6