The animal tuberculoses : and their relation to human tuberculosis / by Ed. Nocard ; translated by H. Scurfield.

THE ANIMAL TUBERCULOSES AND *THEIR RELATION TO HUMAN TUBERCULOSIS*

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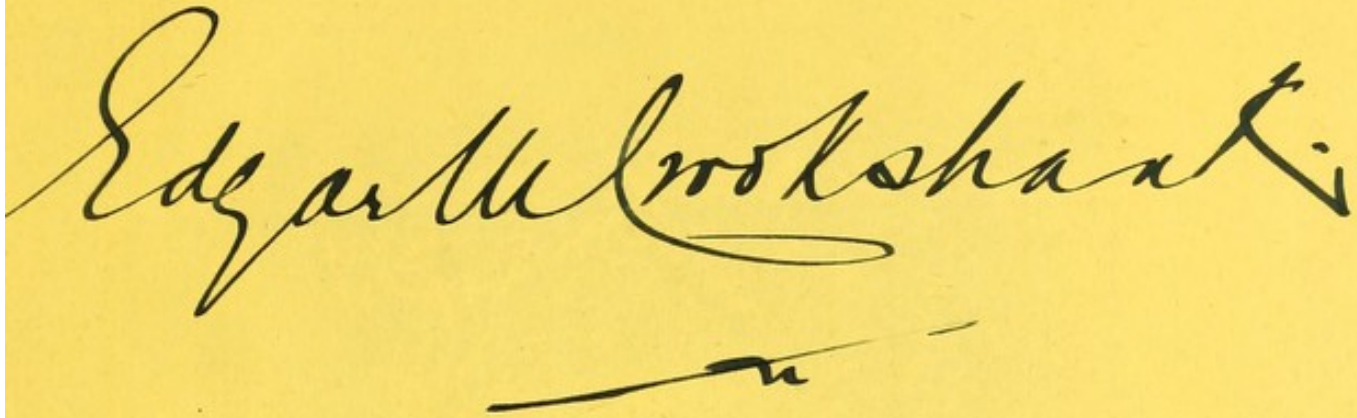

THE

ANIMAL TUBERCULOSES,

AND

THEIR RELATION TO HUMAN TUBERCULOSIS.

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PREFACE.

PERHAPS the chief interest to doctors of human medicine in Professor Nocard's book lies in the demonstration of the small part played by heredity, and the great part played by contagion, in the propagation of bovine tuberculosis.

It seems not unreasonable to suppose that the same is the case for human tuberculosis, and that, if the children of tuberculous parents were protected from infection by cohabitation or ingestion, the importance of heredity as a cause of the disease, or even of the predisposition to it, would dwindle away into insignificance.

In Denmark, Professor Bang has shown how comparatively easy it is to protect cattle from infection, and how a healthy herd may be bred from a severely infected one. A short description of his scheme is given in the Appendix. Such a scheme universally applied would in a few years go far towards eradicating bovine tuberculosis and removing one source of danger to man.

H. SCURFIELD.

SUNDERLAND,
July, 1895.

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INTRODUCTION.

TUBERCULOSIS is a parasitic disease, which is both inoculable and infectious. To Villemin belongs the honour of having demonstrated its contagiousness (1865); to Robert Koch the honour of having isolated its microbe (1892), to which has been given by common consent the name of 'the bacillus of Koch.'

There is no disease in existence which attacks so many different kinds of animals. Not one of our domestic animals is completely refractory to it; they simply vary in their susceptibility, and those which under natural conditions escape infection are unable to withstand experimental inoculation. Our poultry-yards, even, are often decimated by tuberculosis; and the tribute paid by man to it is so heavy that in Paris, according to the latest statistics, more than 23 per cent. of the deaths were due to tuberculosis, and even this high percentage is exceeded in many European towns. Lydtin's name for it—the 'universal panzootic'—is indeed an appropriate one.

Tuberculosis was known to the ancients—tuberculosis of cattle, at any rate. The phthisis of which Columella speaks is certainly our tuberculosis, for he refers to ulceration of the lungs as its last stage: 'Est etiam illa gravis pernicies, cum pulmones exulcerantur, inde tussis

et macies et, ad ultimum, phthisis invadit' (Liv. VI., chap. xiv., 'De Re rusticâ).

Although all tuberculous lesions acknowledge the presence of the causal agent—the bacillus of Koch—nothing is more variable than their appearance. Sometimes they take the form of rounded granulations, hardly as big as a millet-seed, invading all the organs. Sometimes they are great fluctuating masses, filled with yellow pus, which is thick, grumous, full of calcareous grains, and resembles mortar. Sometimes the pleura or peritoneum are covered with hard, glistening, grayish-red, rounded new growths, with more or less long pedicles, and generally heaped together in clusters of variable size, so as to form genuine polypi, which sometimes attain considerable dimensions. Sometimes, again, the lesion consists of an opaque grayish or yellowish matter infiltrating the tissues.

For a long time these varied lesions were thought to be of a very different nature. Laënnec was the first to recognise and proclaim their close relationship. The unity of tuberculosis is admitted everywhere to-day, but for long the idea was combated by the school of Virchow; and the doctrine of Laënnec, although defended by the remarkable work of Charcot, Grancher and Thaon, was abandoned, until quite lately, by the large majority of anatomo-pathologists and doctors. It was in vain that Villemin proved the identity of all these lesions, inoculation into the rabbit or the guinea-pig always giving the same results, whatever the inoculated product, whether sputum, tuberculous nodule, or caseous lung. The opposition only ceased on the day when Robert Koch showed that all these lesions, whatever their microscopical appearance or histological structure, were due to one, always identical, microbe.

Species of Animals attacked.—Although tuberculosis can be transmitted to all the domestic animals by inoculation, it does not by any means, under natural conditions, cause equal ravages in each species.

Cattle come first among its victims, the proportion attacked varying according to the locality. In some places the number of tuberculous cattle is calculated at 10, 15, and 25 per cent. of the whole. In other places the disease is unknown. Nevertheless one would be right in saying that bovine tuberculosis is the contagious disease which exacts the heaviest tribute from agriculture; and it is this form of tuberculosis alone at which French sanitary law takes aim, seeing that the other tuberculoses do not constitute a great danger either to property or to public health.

Horses may be infected under the ordinary conditions of their keeping, and in the horse the disease appears to run a more rapid course and become generalized more easily than in the cow; but, still, one is justified in saying that equine tuberculosis, although the cases of it recorded up to date are fairly numerous, is an exceptional thing.

Among the small ruminants the disease is much rarer still, the sheep and the goat being even markedly refractory to experimental inoculation.

Tuberculosis of the pig is much rarer than that of cattle, but much more common than that of the horse, sheep, or goat, and is, moreover, often generalized in all the organs.

The domestic carnivora do not show a great susceptibility to tuberculosis. At any rate, they are very refractory to the different methods of experimental inoculation, with the exception of intravenous injection. Lately, however, a considerable number of instances of dogs becoming tuberculous owing to contact with phthisical

people have been recorded. Kittens, too, are easily infected by the ingestion of tuberculous material, particularly milk.

Among the birds of the poultry-yard, fowls, pigeons, ducks, turkeys, pheasants, etc., the disease is very common, and often assumes an epidemic character.

The rabbit and the guinea-pig are very rarely tuberculous under natural conditions, but they are, especially the guinea-pig, excellent reagents for the disease. In them it follows a much more rapid course than in the larger species of animals. This allows many experiments to be completed in a short time, and explains the considerable progress that has lately been made in the study of tuberculosis.

The domestic animals of our countries are not the only ones attacked by tuberculosis. It has been found in the camel both in Egypt and in the Kirgheez steppes. Monkeys kept in the different zoological gardens die tuberculous almost to a certainty. Giraffes, antelopes, llamas, gazelles, zebus, etc., in zoological gardens, are also decimated by the disease. Finally, we have authentic records of tuberculosis in the lion, the tiger, the jaguar, the panther, the fox, the jackal, the tapir, the zebra, etc.

We will first study tuberculosis of cattle, and afterwards point out the features peculiar to tuberculosis of the other domestic animals.

THE ANIMAL TUBERCULOSES.

CHAPTER I.

TUBERCULOSIS OF CATTLE.

In ordinary language, bovine tuberculosis is still called 'pulmonary phthisis,' or 'calcareous phthisis'; and, as a matter of fact, the progressive wasting and marasmus of the affected animals are usually the last result of lesions which are pulmonary, and which are infiltrated with calcareous salts. At one time the disease was known as 'pommelière,' from the shape and considerable size sometimes assumed by the lesions of the lung or serous membranes. The word 'tubercle' has a similar origin. The old authors, notably Hurtrel d'Arboval, liken to 'tubercles' either the glands which are hypertrophied, indurated, and infiltrated with specific nodules, or the mammillated tumours which grow on the surface of the serous membranes.

When the disease is localized in the pleura or peritoneum, as it frequently is, the Germans and English call it 'Perlsucht' or 'pearl disease,' because the tubercular nodules of the serous membranes, before they get too old, bear a strong resemblance to pearls.

Lesions of Tuberculosis.—Nothing is more variable than the localization of bovine tuberculosis. It may attack any of the organs. The lung and lymphatic glands come first in order of frequency; next the serous membranes; then the liver, intestine, and uterus; and lastly the spleen, the medulla of the bones, the joints, the udder, the skin, etc. Naturally, the symptoms of the disease vary greatly according to the organ or organs attacked.

From a clinical point of view two great divisions are made, viz.: pulmonary tuberculosis and abdominal tuberculosis. From an anatomical point of view three chief divisions are made: (1) Tuberculosis of the organs; (2) tuberculosis of the serous membranes; (3) tuberculosis of the lymphatic glands. In most cases, undoubtedly, these three forms coexist in the same subject, but, still, it is quite common to see animals succumb, either to intense glandular tuberculosis or to enormous tuberculous growths of the pleura or peritoneum, without the process having attacked the neighbouring viscera. It would almost seem as if there were three varieties of the bacillus of Koch, each with a preference for one particular tissue or culture medium.

Statistics of the large abattoirs show that, of the tuberculous animals, 40 per cent. are affected in both lung and pleura; 20 to 25 per cent. in the lung alone; 15 to 20 per cent. in the serous membranes alone (pleura and peritoneum); the remainder comprising either generalized lesions of all the organs (acute phthisis), or lesions localized to the glands, the genital organs, mammæ, tongue, osseous tissue, etc.

The glands which collect the lymph from the organs attacked are always more or less severely affected. In fact, in many cases, when the animal is slaughtered quite at the commencement of the disease, tuberculous nodules are only

found in the bronchial or mediastinal glands; and the pulmonary lesion which has served as the entrance-gate for the contagion either eludes the most careful search, or is only represented by a minute focus of disease, much less important than the glandular alterations, which it has preceded and caused.

1. **Pulmonary Tuberculosis.**—As a general rule, the tuberculous lung is bulky and heavy. It only collapses incompletely. Its weight may reach 40, 50, 60 lbs., or more. Its surface is covered with knobs, over which the pleura is thickened, and sometimes shaggy with fibrinous growths which are either free or adherent to the parietal layer of the membrane. These knobs are irregular, rounded, and very variable as to size, and consist of accumulations of tuberculous lesions. They are sometimes hard and tough, and creak under the instrument used to cut them; on section their tissue is seen to be intensely yellow, rough to the touch, and softened in places, and when the caseous substance is rubbed between the fingers, hard grains are felt in it. Sometimes, again, the knobs show more or less obscure fluctuation, and incision into them gives vent to a yellow grumous, mortar-like, thick material; in this case the masses of tubercular nodules have undergone varying degrees of caseous and calcareous degeneration.

The knobs are usually surrounded by healthy lung tissue, which has kept its normal pink colour, suppleness and elasticity. Sometimes, however, they set up round themselves an actual hepatization; and at other times, again, they are, as it were, isolated in the centre of a more or less thick ring of white very tough fibrous sclerosed tissue; in the latter case the tuberculous lesion proper, whether it be hard or softened, is always of small size.

But these are not the only specific lesions of the lung.

Between the large tumours, either under the pleura or in the depth of the lung substance, whether it be hepatized or permeable, there are generally found the miliary nodules which constitute the most characteristic feature of the disease.

The appearance of a nodule, even when looked at with the naked eye, permits one to guess its age approximately.

When it is quite recent, it is a small rounded body, which is semi-transparent, grayish, homogeneous throughout, about as big as a millet-seed, and sometimes has at its periphery a slight inflammatory zone. This is the 'gray granulation' of Laënnec, and is hardly ever seen except in animals slaughtered during the course of a generalized tuberculosis.

A little later there appears, in the centre of the small gray translucid mass with its red halo, an opaque yellowish-white point. Gradually this point increases in size, and at the same time the nodule grows larger, and its peripheral parts, becoming gradually denser, form a kind of fibrous membrane, which is more or less thick and tough. This is the 'crude tubercle' of Laënnec, and in cattle the central opaque, yellowish, caseous material is always rapidly infiltrated by calcareous salts.

In rare cases the nodules remain isolated. Usually in the immediate neighbourhood of the primary nodule, others soon develop, which may become enclosed with the first in a single fibrous shell formed from the connective tissue of the organ.

In this manner accumulations of nodules of all sizes are found, and when the disease has existed a long time, many are softened and converted into genuine tuberculous abscesses with thick fibrous walls, and containing very viscid grumous pus, which is usually of a yellowish or greenish colour. As long as these abscesses are intact,

their contents escape fermentation and remain free from smell, but they may ulcerate through the wall of a large bronchus, partially empty themselves into it, and in this manner form a cavity, the contents of which give off a fœtid odour.

The outline of the wall of the tuberculous abscess or cavity is always irregular and tortuous. The cavity is often traversed by more or less thick and tough bands, always covered with fleshy buds. These are branches of arteries or nerves, or else the large bronchi of the region of the lung attacked by the tuberculous lesion.

Sometimes the lung is found to be crowded with rounded nodules, as big as a hazel-nut or a walnut, dirty white in colour, of a firm consistence throughout, and free from central softening. These are the 'fibrous tubercles' of the old authors, and are fairly common in the horse.

One may also find foci of caseous pneumonia, varying in size, and slate-coloured or yellowish in tint, which are developed by preference in the anterior lobe of the lung, and soon undergo caseous or purulent softening. Sometimes the lung is solidified en bloc, and presents on section the appearance and consistence of Roquefort cheese. The compact gray mass is traversed by irregular tortuous cavities more or less full of muco-pus, which is generally fœtid. These cavities are caused by the dilatation of small bronchi or terminal bronchioles.

Sometimes, again, this anterior lobe of the lung is wholly or partially collapsed and purple-red in colour. This is not hepatization or splenization, but simply obstruction. The tissue, gorged with blood, has been cut off from all access to inspired air by the obstruction of its chief bronchial branch. Owing to the transparency of the serous membrane, it is possible to ascertain that

some of the lobules of the obstructed region are invaded by small rounded yellowish-white soft bodies arranged in the form of a cluster along the bronchiole, which officiates for the lobule. These fluctuating bodies are in reality small bronchial dilatations full of yellow, extremely viscid muco-pus.

The *bronchi* are very frequently the seat of a well-marked chronic inflammation, which is shown by the yellowish, sometimes fœtid, thick muco-pus contained in them, and by the thickening and folding of their mucous lining. Sometimes the mucous membrane is infiltrated by gray, yellowish or caseous granulations; sometimes it is covered with deep ulcerations with irregular and indurated margins, and a reddish floor picked out here and there with little islets of caseous matter.

The very small bronchi are also frequently encircled by accumulations of miliary nodules developed in their immediate neighbourhood, which first compress, then narrow, and finally obstruct them altogether. As a result we have the cutting off of the air-supply of the pulmonary tissue, and when the mucous membrane is irritated, the ampullary dilatations and collections of muco-pus before described.

The *trachea* and *larynx* are equally liable to be invaded by miliary nodules, which develop either in the sub-mucous connective tissue or in the depth of the mucous membrane. These nodules, which are either isolated, confluent or arranged in a linear series, pass quickly through all the phases of their evolution, and the softening of their centres is rapidly followed by the formation of more or less extensive ulcers with jagged and indurated margins, offshoots from which lay bare specks of bright yellow tuberculous material.

The glands which collect the lymph from the region of

the lung attacked by the nodules usually take part in the lesion. They become hypertrophied, indurated and knotty. On section, their gray-pink succulent tissue seems, as it were, stuffed with a variable number of yellow, hard, calcified, projecting miliary nodules. This is an early stage. A little later the nodules increase in number, and coalesce into one dry fibrous mass, infiltrated with calcareous salts, which takes up a third, a half, or three-quarters of the glands, and the scalloped outline of which, with its yellow colour, shows up clearly against the gray background of the tissue proper of the organ. Later still, all this mass undergoes caseous softening, and the degenerated gland then becomes nothing more than a fibrous pouch full of puriform, grumous, yellow, mortar-like, semi-liquid material.

2. **Tuberculosis of the Serous Membranes.** — In this variety of the disease the pleura, the peritoneum, the synovial membranes, and even the meninges, may be attacked, whilst the organs remain free. At the outset, very small, transparent, grayish-pink, rounded granulations develop in the thickness of the serous membrane and give it a granular appearance. Each granulation is the centre of an area of abnormal vascularity and connective-tissue formation. As the multiplication of the granulations and the connective-tissue hyperplasia go on increasing side by side, important lesions are soon the result, which project from the serous membrane, and are now only united to it by a pedicle, which is sometimes very long, and always very tough. These lesions consist of small rounded or mechanically-flattened tumours, which are firm, dense, whitish, have a shining surface like mother-of-pearl, and are sometimes scattered over the surface of the serous membrane, but more often heaped together in the form of bunches, cauliflower-

growths, or polypi of considerable size. These pearly tumours are rather soft at first, but soon undergo calcareous infiltration. Their contents are always firm, hard, dry, rough on section, and enclosed in a thick, tough, fibrous case.

These massive lesions are specially noticed on the *pleura* or *peritoneum*. The lesions found on the *synovial membranes* of joints or tendons are always much less marked; and on the cerebral or spinal *meninges* the form usually observed is the gray granulation or 'miliary tubercle.'

The most common tuberculous lesion of the *pericardium*, too, is the eruption of gray granulations, or miliary tubercles; but sometimes the two layers of the serous membrane are transformed into a stratum of tuberculous material which is 3, 4, 5, or more centimetres in thickness, yellowish-white in colour, firm in consistence, and has little tendency to become caseous. This fibrous cuirass causes atrophy of the cardiac muscle, and greatly impedes its action.

3. **Tuberculosis of the Glands.**—It is fairly common to find at the autopsy of animals which have died, or been slaughtered for the butcher, tuberculous lesions exclusively localized in the lymphatic glands. Sometimes only the pharyngeal, superior and inferior cervical, and substernal glands are hypertrophied, indurated and infiltrated by nodules; sometimes only the bronchial and mediastinal; and, lastly, sometimes only the glands of the abdominal cavity—mesenteric, sublumbar, those of the hilum of the liver, etc.

Whatever be the group of glands attacked, the characteristic of this variety of the disease is the complete absence or insignificance of the tuberculous lesions of the organ with which the affected glands are connected.

Sometimes, indeed, in spite of the most minute examination, it is impossible to find the spot at which the contagion effected its entry. Once carried by the lymphatic circulation as far as the nearest gland, the tubercle bacilli take up their abode in it, multiply, and gradually invade and destroy it. After destroying the first gland, they effect a passage to its next-door neighbour, and treat it in the same way. In this manner a whole group of glands may be attacked and destroyed by the contagion, without the organ showing a trace of its passage through.

The glands, which are at first hypertrophied, indurated, knotty, and infiltrated by yellow and calcified miliary nodules, speedily undergo all the changes before described. On section, a yellow, dry, hard, fibrous, wrinkled material is found to have taken the place of the normal yellowish-gray succulent tissue of the gland. 'The mediastina were transformed into a mass of tubercles arranged like the cotyledons of a cow which has just calved,' wrote Hurtrel d'Arboval. In this position it is common to find glands, 20 to 30 centimetres long, encircling and compressing the gullet, nerves, and great vessels. For long these lesions were looked upon and described as belonging to glandular leukæmia, but in 1885 I was able to make certain, in the case of specimens obtained by M. Cagny, that they really were tuberculous. Both bacteriological examination and inoculation left no doubt on the subject; and since that time I have often had occasion to repeat these observations and to verify the results then obtained.

4. **Abdominal Tuberculosis.**—The organs of the abdomen most frequently attacked are the peritoneum and the glands. Next in order come the intestine, the liver, the uterus and its appendages, and last of all the spleen.

Miliary tubercular nodules often develop either in the thickness of the mucous membrane, or in the submucous cellular tissue of the *intestine*. These nodules may be isolated or in groups. They always quickly undergo softening, and empty their contents into the intestinal canal, giving rise in this way to small mucous ulcers, which have no tendency to heal. These ulcers, which are at first very small, isolated, and lenticular, gradually increase in extent. They look as if they had been cut out vertically, and their margins are more or less sinuous, and always thick and hard. They are particularly numerous in the last part of the small intestine and the cæcum. They are especially found in connection with the solitary glands and Peyer's patches, but are not confined to these positions. At the site of the ulcers the serous surface is nearly always thickened and infiltrated, and is often adherent to the neighbouring organs. Perforation very seldom occurs.

It is not uncommon to find the mesenteric glands tuberculous, when it is impossible to discover in the intestinal mucous membrane the place where the bacillus has effected its entry.

The *liver* is often attacked. Miliary tubercle of the liver is rare. The lesion generally takes the form of more or less bulky masses scattered irregularly throughout the substance of the organ. These masses are sometimes so numerous, that the liver is altered in shape and indented, and acquires a weight of 40 to 60 lbs., or more. Tubercular nodules of the liver seem to undergo softening more rapidly and more completely than those of other viscera.

Severe tuberculous affection of the *uterus* is fairly common. The lesions are found either in the substance of the mucous membrane or in the submucous tissue.

One horn alone may be attacked. The organ may grow so large as to suggest the presence of a fœtus. On dissection, the mucous membrane is found to be crowded with miliary nodules. These nodules are usually caseous and softened, in which case the cavity of the organ is full of yellowish grumous muco-pus, and the surface of its mucous membrane is riddled with ulcers. But sometimes the nodules do not undergo caseation, and the mucous membrane is then much thickened, very hard and white, and looks as if it were attacked by scirrhus: histological examination, however, shows that it is infiltrated by tuberculous follicles which are very rich in giant-cells and very poor in bacilli.

Tuberculous lesions of the *vagina* are very rare, but those of the Fallopian tubes are more common.

Tuberculosis of the *kidney* is not very rare, but careful dissection generally shows that the tuberculous masses have developed either in the deep layer of the capsule or in the subcapsular connective tissue. The tissue of the organ is compressed by the new growth, but has not taken part in its formation.

There are in existence some records of tuberculosis of the mucous membrane of the *bladder*, which gave rise to incurable hæmaturia and a rapidly fatal termination.

The *spleen* is rarely the site of tuberculous lesions. In cases of recent generalization, its tissue may be crowded with an infinite number of minute gray granulations; but, as a rule, the lesions, when met with, are few, comparatively bulky, nodose, calcified, and provided with a tough fibrous envelope.

The *bones* are seldom attacked, but the marrow of the bones is an excellent culture medium for the tubercle bacillus. In cases of generalized disease, the marrow of the bones is, like the spleen, crowded with fine gray

granulations, more numerous, perhaps, than in any other tissue. Sometimes old lesions of the ribs, the bodies of the vertebræ, the sternum, the articular extremities of the long bones, etc., are met with. These old lesions take the form either of yellowish-white, fairly firm, rounded nodosities of the size of a pea or a walnut, or of a grayish or yellowish caseous infiltration. The lesions are developed in the spongy tissue, and the compact tissue in their neighbourhood seems to be irritated, is increased in thickness, and often is also covered with a more or less thick and even layer of subperiosteal young bony tissue.

Sometimes, lastly, the tuberculous growths soften and produce fistulæ and eruption of the caseous contents, either externally or into the neighbouring joint.

In the *udder* the initial lesion generally assumes the form of a slowly-progressive sclerosis. The interlobular connective tissue, normally so scanty, becomes gradually thickened and fibrous, and can be seen to be infiltrated by minute miliary granulations, which are gray, or yellow and caseous, and scattered here and there in varying numbers. At a later stage these granulations are larger and more numerous, and become softened or calcified. The glandular tissue is, as it were, smothered by the hypertrophy and fibrous transformation of the interstitial connective tissue. The large excretory ducts are here and there dilated by masses of yellow caseous material, which is very rich in bacilli, and the walls of the ducts are thickened, fibrous and sacculated, and sometimes infiltrated by minute yellowish granulations.

Tuberculous lesions of the *testicles* are very rare, but they may occur in the form of fibrous nodules, about as big as a hazel-nut or an almond, or else in the form of yellow, calcified or softened miliary nodules. They

may be developed either in the substance of the gland itself, or in the epididymis. Tuberculosis of the *vagina*, *spermatic cord*, and *prostate* have also been described.

The *muscular tissue* seems to be unsuitable for the growth of tubercle. Intramuscular tuberculous lesions, even in cases of generalized disease, are most rare. They are occasionally found, however, and, when they do occur, take the form of small tumours, of the size of a pea, a hazel-nut or a marble, of a dirty white colour and a tough consistence. They very rarely undergo softening, and the muscular tissue in their immediate neighbourhood is sclerosed.

I have several times seen cases of tuberculosis of the *tongue*. The appearance of the organ is like that of actinomycosis : it is hard, rigid and nodose. On section the tongue tissue is seen to be replaced here and there, especially in the part underlying the mucous membrane at the base of the organ, by a whitish tough tissue resembling a new growth, in which microscopical examination reveals numerous tuberculous follicles, which are very rich in giant-cells and in the specific bacilli.

I have been able to collect several recorded instances of tuberculosis of the *subcutaneous cellular tissue*. In one case, for which I am indebted to the kindness of M. Rossignol, the tail was transformed into a knotty staff by the development under the epidermis of a large number of tumours, varying in size from that of a hazel-nut to that of a walnut, the skin itself being intact. These tumours had the consistence of india-rubber, their tissue, which was of a dirty-white colour, was homogeneous throughout, and they seem to me to be analogous to the scrofulous gummata of man.

It is obvious that, in cases of generalized disease or acute miliary tuberculosis, all the abdominal organs,

liver, spleen, kidneys, etc., will, like the lung, be crowded with an infinity of transparent gray granulations hardly as big as a millet-seed. When all these numerous lesions have reached the same stage of their evolution, it shows that generalization has taken place at the same instant by the blood-stream.

Histological Study of the Lesions.—We have seen that tuberculous lesions are found under three very different aspects: (1) In the form of very small granulations from $\frac{1}{10}$ to 1 millimetre in diameter, which are grayish, translucid, and sometimes have a yellowish-white opaque centre; (2) in the form of mammillated, yellowish, hard, calcified masses, varying in size from that of a pea to that of a walnut or apple; (3) in the form of a grayish or yellowish opaque infiltration of the tissues.

Histological study shows that, in spite of these different aspects, the disease is identical. The tumours and the infiltrations, when they come to be analyzed, are simply tuberculous granulations, calcified and encysted in the one case, and caseated but not encysted in the other.

The gray granulation, when studied by means of fine sections stained with picrocarmine, is found to consist of three distinct parts: (1) a central amorphous portion, orange-yellow in colour and either finely granular or reflecting the light brilliantly, with irregular slits or gaps in it—(here the anatomical elements have undergone a vitreous or caseous degeneration; here there is also generally, but not necessarily, a multinucleated giant-cell); (2) a zone of epithelioid cells with deeply-stained nuclei arranged concentrically around the caseous portion; (3) a girdle of embryonic elements with large, deeply pink-stained nuclei, sprinkled with fusiform cells, arranged concentrically in more or less numerous and closely-packed layers.

The older the granulation, the more extensive is the central caseous portion; and at the outset the caseous centre may be entirely absent, the elementary tuberculous nodule or tuberculous follicle then consisting simply of a small mass of leucocytes arranged in closely-packed concentric rows. At a later stage, as the caseation progresses, opaque hard grains appear here and there in the caseous material—the first signs of calcareous infiltration.

The anatomical characteristics of the tuberculous granulation may be summed up thus:

(1) The nodular form of the mass.

(2) The tendency of the central portion to become caseous.

(3) The frequent occurrence of giant-cells in the centre.

(4) The concentric arrangement of the peripheral cellular elements.

(5) The complete absence of vessels.

The 'miliary tubercle' consists of the aggregation of a certain number of elementary granulations in a single fibro-cellular envelope, the toughness of which gradually increases.

'Tuberculous masses,' whether small or great, are collections of a variable number of caseous, calcareous or softened 'miliary tubercles' surrounded by a more or less thick and tough fibrous shell.

The 'caseous infiltration' of the tissues is the result of the development of a considerable number of tuberculous follicles, whose peripheral elements, having no tendency to undergo fibrous transformation, remain in the cellular state and retain their concentric arrangement, until they are attacked, like the centre of the follicle, by caseous degeneration. This latter form of lesion rarely undergoes calcification.

The collection of cells which characterizes the initial phase of a tuberculous follicle, according to Baumgarten, is the result of the proliferation of the fixed cells of the cellular tissue. According to Metchnikoff, on the other hand, the collection of cells is due to the immigration of leucocytes; and the tuberculous follicle is the sign of the battle waged by the organism against the parasitic invader, and simply a modification of phagocytosis.

For long it was thought that the anatomical arrangement just described was specific, and that, wherever it was found, the existence of tuberculosis could be assumed. This is not the case, however, for several parasitic affections are now known to cause the formation of granulations identical with those of tuberculosis. The tuberculous follicle, therefore, though well defined histologically, has no precise signification as regards the diagnosis of the disease. It will be sufficient to mention that the egg of the strongylus, the demodex of Laulanié, the zoogloeæ, the bacillus of Courmont, the streptothrix of farcin-du-bœuf, the micro-organism of actinomycosis, etc., cause the formation of follicles identical with those of the bacillus of Koch.

Further, Hippolyte Martin has shown that, if spores of lycopodium, olive-oil, mercury, etc., previously sterilized, are injected into the peritoneal cavity of experimental animals, an absolutely typical tuberculous follicle is formed around each particle of the inert substance injected.

The feature which shows the specific nature of a tuberculous follicle, is not only that it can be transmitted through a series of animals by inoculation, as H. Martin used to think: it is the constant presence of the essential agent of the disease.

From the foregoing remarks it is easy to understand

how the specific nature of tuberculosis, which was asserted by Villemin in 1865 on the strength of the most rigorous and demonstrative experiments, was not admitted by the majority of doctors till the day when Robert Koch discovered its microbe, showed the means of ascertaining its presence in all tuberculous products, and demonstrated the possibility of cultivating it outside the organism on artificial nutrient media, and of reproducing the disease by the inoculation of pure cultures (1882). The announcement of these facts caused a widespread excitement. Everywhere the accuracy of Koch's assertions was tested, and everywhere it was verified; and it may truthfully be said that no discovery has ever made the conquest of the scientific world with such rapidity. The practice of medicine was thus enriched with an infallible means of controlling the diagnosis of pulmonary tuberculosis—at any rate, in cases of that disease accompanied by expectoration.

The tubercle bacillus, which should in fairness still be called 'the bacillus of Koch,' exists in all tuberculous lesions and all tuberculous products. To demonstrate it, a special method of staining is necessary, which belongs to it alone, and which is so effective that it is comparatively easy to recognise the bacilli of tuberculosis amidst the innumerable microbes which the saliva or expectoration of a suspected animal contains.

The bacillus of Koch is very small and slender; its length varies from 3 to 5 μ ($\frac{1}{2}$ or $\frac{2}{3}$ of the diameter of a red blood-corpuscle), and its breadth from ·2 μ to ·3 μ. It is straight or slightly sinuous. In recent lesions it appears homogeneous throughout its whole length; but in old lesions and in pus and sputum it appears to be formed of ovoid grains arranged end to end in a linear series.

Koch succeeded in demonstrating it in the substance of the tissues by means of a special method of staining requiring delicate manipulation. This method has at present only a historic interest, because

soon after the publication of Koch's work, Ehrlich, his pupil, made known a much more simple method, which Koch, moreover, soon afterwards adopted. It consists in treating the suspected products, whether fine sections or cover-glasses smeared with the product, with the following solution :

Aniline water	10 cc.
Absolute alcohol	1 „
Concentrated alcoholic solution of fuchsin (rubine) or of violet (Gentian violet or Paris violet) ...	1 „

This solution may be prepared as required, and the proportions need not be calculated with mathematical precision.

At the ordinary temperature of a room, the staining should be continued for twelve, fifteen, or, better still, twenty-four hours. For staining smeared cover-glasses the solution may be used hot, just so hot that steam rises from its surface, and an immersion in this for five or ten minutes is sufficient.

After being stained, the section or cover-glass is washed in filtered water, and then plunged into a 33 per cent. solution of nitric acid, or, better still, into a 10 per cent. alcoholic solution of nitric acid. The time of contact with the acid should vary, according to the thickness of the section, from thirty seconds to two minutes, and the effect should be such that, after a second washing, the section or cover-glass should be entirely decolourized or have only a faint pink or bluish tint.

The staining process is then finished by colouring the background with an aqueous solution of vesuvin or Bismarck brown ; the preparation is then mounted in Canada balsam and examined.

For the examination a homogeneous immersion objective and an Abbé's condenser must be used.

It will then be found that the bacilli of tuberculosis alone have retained the primary coloration (red or violet), and that all the other microbes and all the anatomical elements of the tissue have taken on the background stain, whether yellowy-brown, blue or pink.

Recently a great many staining procedures for Koch's bacillus have been made known. The most practical and simple method is that of Ziehl-Kühne, for which the staining liquid consists of the following solution :

Carbolic acid (5 per cent. solution)	90 grammes.
Alcohol (90 per cent.)	10 „
Fuchsin rubine	1 „

(The solution to be filtered before use.)

The cover-glasses or sections are first plunged into alcohol, then into the staining solution, which may be used cold, and in which they ought to remain from ten to forty minutes. They are then washed, then decolourized in 33 per cent. nitric acid, or, better still, 20 per cent. sulphuric acid. They are then washed again, then given the contrast stain with methyl-blue or Bismarck brown, and mounted.

Ziehl's solution has the advantage that it keeps; Ehrlich's must be used fresh, for after five or six days it loses much of its staining power.

Koch's bacilli are not equally numerous in all tuberculous lesions. That is one of the obscure points in the history of the disease. The number of bacilli present has no relation to the importance of the lesions. The most careful examination of one enormous nodule will only reveal the presence of a very few bacilli, while another much smaller nodule will contain great numbers of them. As a general rule, when there are many giant-cells, there are few bacilli. Sometimes, doubtless, a careful examination of a preparation does not enable one to see the microbes, because they are hidden by a superficial layer of the tissue of the section. Again, one often sees grains coloured violet or red, according to the method of staining adopted, which are probably bacilli cut perpendicularly or obliquely to their axis.

Culture of the Bacillus.—At first the question was asked: If this rodlet indeed played a part in the evolution of the disease, was it a living entity capable of reproduction and multiplication? Had not Koch mistaken for the agents of tuberculosis inert bodies—crystals, for example—which possessed the chemical properties just indicated? Koch replied victoriously. After a thousand difficulties, he succeeded in cultivating the microbe, and he reproduced tuberculosis with all its characteristics by inoculating the cultivation.

The cultivation of the microbe of tuberculosis is an extremely difficult thing, and Koch tried in vain all the nutrient media which

had been generally used up to that time. With the characteristic patience of the Germans, he made no publication till he had found a medium which was almost suitable.

After many attempts, he succeeded in obtaining, by heating serum (expressed during the clotting of blood) to from 65° to 68° C., a transparent gelatinous medium, on the surface of which the contents of young tuberculous nodules would grow, though very slowly. For fourteen or fifteen days the seed sown seemed to remain inert, but at the end of that time it grew slowly in some of the tubes in the form of small, powdery, whitish, dry scales, which were simply heaps of bacilli. The difficulty of the cultivation is so great that, at first, most of those who attempted it failed, although they followed most minutely the technique indicated by Koch; they only succeeded in obtaining an excessively scanty growth, which it was impossible to transplant. As a matter of fact, it was necessary to take the precaution of sowing at the same time a large number of tubes, say twenty, or thirty, or fifty, and of leaving them in the incubator for fifteen days. It was also necessary to sow in each tube a considerable amount of the substance, carefully broken up. Growth then took place in two or three tubes, which served to sow a new series. In this new series of tubes a much greater number were successful, and, so, by increasing the number of series, the growth developed more easily and became more abundant.

M. Roux and I have shown that the serum becomes a more favourable medium if there is added to it, before solidification, a little peptone, sugar and salt. It was by sowing from nodules of a pheasant's liver in such a medium, that we obtained cultures much more rich and abundant than those of Koch.

But it is especially by the addition to the serum, before solidification, of 5 to 8 per cent. of glycerine, that we have succeeded in obtaining an incomparable culture medium. On this the bacillus grows abundantly and very rapidly. Moreover, the addition of glycerine to nutrient gelatine, or even bouillon, converts them into media which are very favourable for the growth of the bacillus of Koch. The growth stands out from the surface of the solid medium, and takes the form of small yellowish-white lichenoid grains, which are dry, dense, and difficult to crush, each grain containing thousands of bacilli. In the case of a liquid medium, the growth takes place either at the bottom of the vessel in the form of small yellowish-white grains, which are mammillated and difficult to crush, or at the surface

in the form of a thick dirty-white film. The growth gives off a very pleasant flowery odour, reminding one of the smell of the syringa or orange-blossom. One can also obtain very fine cultures of Koch's bacillus on potatoes or beetroot impregnated with glycerine.

The possibility of the culture of the bacillus of Koch in a liquid medium constituted a real advance in the better study of the biology of the microbe. It has allowed of the isolation of the toxins secreted by the bacillus, and we shall see what marvellous properties the German savant attributed to them.

Symptoms.—Bovine tuberculosis is a disease of very slow evolution. Its presence is often compatible with all the appearances of health, and it may exist for months and years without anything causing one to suspect its existence. The clinical diagnosis of it is extremely difficult even at an advanced period of its evolution.

The symptoms vary much according to the form, and according to the localization of the disease.

A. **Pulmonary Tuberculosis.**—This is much the most common form, and it is also the most dangerous, because the virulent matter, which the softened nodules empty into the bronchi, is shot forth from the mouth during the fits of coughing. This expectorated matter becomes dried and reduced to a powder, and infects the neighbours of the affected animal, either by penetrating into the respiratory apparatus with the inspired air or by penetrating into the digestive tube with the food, whether liquid or solid.

It is customary to describe three stages or degrees in the evolution of pulmonary tuberculosis, and its study and description are thereby rendered more easy.

First Degree.—Quite at the outset there may be absolutely no symptoms. A careful and attentive cow-keeper will tell you that such and such a beast in his stable coughs at long intervals, perhaps, when the doors are

opened in the morning to let in fresh air, when it is made to stand up or walk, when it is made to drink, or when it is given dusty food: the cough is a slight one, dry, a little whistling, and in short paroxysms.

If it is a beast of burden, one notices that it breathes a little more quickly than the others, especially when going up a hill. If it is a cow, it is common for it to become amorous. It bellows incessantly for the bull, which does not succeed in fecundating it. This is sometimes the first sign of the disease.

So far there is nothing abnormal in the general state of the subject. It is lively, it eats with appetite, its hair is glossy, its skin is neither dry nor adherent, there is no exaggerated sensibility in the region of the kidneys, the secretion of milk is not diminished, the animal remains in good condition, and may even fatten as quickly as its fellows.

If it were possible to follow the animal closely and to take its temperature daily, morning and evening, one might observe sudden and temporary rises of temperature, without appreciable cause, to the extent of 1° to 1½° C. and more.

Whilst, in man, doctors recognise commencing tuberculosis fairly easily, it is not the same here. The indocility of the subjects, the huge dimensions of the organ to be examined, the thickness of the skin and of the thoracic walls, the presence of hair, the close application to the thorax and the slight mobility of the forelimbs (causing the concealment of a considerable portion of the lung), the proximity of the rumen (the noises of which are easily conveyed to the ear)—all these unfavourable conditions bring about the result that, at this period, the stethoscopic signs, which are very vague, even in man, escape the most careful examination.

Second Degree.—The disease is more pronounced. The hair has lost its gloss, and become dull and bristly. The skin is adherent and dry, and, if taken between the fingers, is with difficulty detached from the subjacent tissues, especially at the level of the last ribs, and the fold formed is not effaced for a long time. The region of the kidneys shows an abnormal sensibility to pressure, and the animal, when pinched there, shrinks under the touch. All these signs are vague enough, but butchers and breeders know how to take advantage of them. These signs, moreover, acquire a real value when they occur in a stable known to be infected.

Pressure on the ribs or the region of the kidneys causes groaning and coughing. The cough is still dry, hoarse, whistling and paroxysmal, but more frequent and manifestly painful; sometimes, however, it is thick, deep, and followed by a gurgling back towards the chest, and one guesses that mucus is circulating in the bronchial tubes. Occasionally the mucus may be shot forth from the mouth during a violent and long fit of coughing, and may then be seen to be purulent, thick, viscid, and yellow. The diagnosis may then be made certain by examining it under the microscope, or inoculating it.

Unfortunately these cases are exceptional. The cough does indeed set the bronchial mucus in motion, but in most cases the mucus does not get past the pharynx, for it is at once swallowed by the animal. By standing to the left of the animal, it is easy to see that, after each fit of coughing, a movement of deglutition takes place; and the eyes can easily follow the bolus in its œsophageal journey for the entire length of the jugular groove. In this manner tuberculosis of the intestine, mesenteric glands, and liver may be set up, without there being

generalization in the true sense of the word—that is to say, intervention of the blood-stream.

The respiration is modified in rhythm and frequency; it becomes hurried, short and interrupted, especially during work. Often at the end of expiration a furrow is formed along the hypochondrium from flank to breast-bone, showing that the muscles of expiration have to contract forcibly.

Auscultation and percussion may now give useful information. If large vegetations of the pleura exist, or if tuberculous masses of a certain size have developed in the superficial layers of the lung, percussion announces their presence by the dull sound given at their level, and auscultation by the absence of the vesicular murmur, and sometimes by the positive evidence of crepitant râles, or of a friction murmur very different from that of acute pleurisy at an early stage. If the softened pulmonary tumour has partially emptied itself into a large bronchus, a cavernous or amphoric murmur or a splashing sound may be observed, and the dulness will be replaced by tympanitic resonance. But this is an exceptional occurrence. Usually the lesions are too much scattered throughout the mass of the organ, and too small for discovery by means of percussion, and the vesicular murmur is obtained all over, though it is coarser than usual, and accompanied here and there by bronchial râles, crepitation, or sibilant sounds.

In addition to these signs derived from the pulmonary lesion, we soon get digestive disturbances, mostly of a glandular origin. The appetite becomes diminished and capricious. Rumination is delayed, is slow and irregular, and only accomplished during rest. After a meal meteorism is frequently noticed, but does not cause much discomfort, and does not last long. All these dis-

turbances are due to the compression of the œsophagus by the tubercular glands of the mediastina.

At this period the secretion of milk is diminished, and its quality alters. It becomes slightly serous and has a faint bluish tint. Nevertheless it does not look bad, and is still saleable, and if the udder is not the seat of specific lesions, it may be consumed without danger.

Third Degree.—At this period the evolution of the disease becomes rapid. The affected animals become really phthisical, and the wasting is more marked from day to day. The skin is bound down to the bones, and the hair is dull and bristling. The whole expression denotes dejection and prostration. The eyes are watery and sink back in their orbits, and the lids are stuck up with scaly matter. A grumous, fœtid, yellow discharge trickles from the nostrils and soils the muzzle, which the sick animal has not strength to clean with a lick of its tongue. The animal remains standing up persistently, with its shoulders stretched apart, as if to facilitate the expansion of the chest. The breathing is quickened, short and jerky ; the cough is frequent, feeble, and painful. Pinching the back sets up prolonged fits of coughing, and at the same time makes the animal shrink.

The stethoscopic signs now leave no doubt as to the nature and severity of the lesions. Percussion reveals more or less extensive areas of dulness, with tympanitic resonance over the cavities, which are near the surface. On auscultation, cavernous râles, amphoric murmurs and splashing sounds are easily perceived.

Death supervenes from asphyxia or exhaustion.

These are not the only symptoms noticed during the last stage of the disease. Usually the lesions are generalized in most of the organs, and as a result we may notice : persistent meteorism, ptyalism with dys-

phagia, owing to tubercle of the pharyngeal glands ; colic, with alternations of constipation and diarrhœa, owing to tubercle of the intestine and mesenteric glands ; a purulent vaginal discharge, owing to tubercle of the uterus ; hæmaturia, owing to tubercle of the bladder ; hypertrophy and knobby induration of all the lymphatic glands which can be examined, such as the submaxillary, those at the base of the ear, the superior and inferior cervical, the substernal, and those of the shoulder, elbow, fold of the flank, groin, udder, popliteal space, etc. ; lameness or arthritis, owing to tubercle of bones or joints ; symptoms of giddiness, epilepsy or paralysis, owing to tubercle of the nervous centres or meninges, etc.

Lesions of the pericardium, for a long time, make no sign of their presence, but eventually they set up symptoms quite comparable to those of traumatic pericarditis.

B. **Abdominal Tuberculosis.**—The tuberculous lesions may be exclusively localized in the organs of the abdominal cavity (intestine, glands, liver, peritoneum, uterus), the thoracic cavity being entirely free. In such a case the clinical diagnosis is almost impossible, and one can only guess the existence of the disease by taking notice of certain changes in the general condition and behaviour of the animals.

One may suspect tubercular peritonitis from disorders of the genital apparatus, which usually shares the infection. The period of heat is prolonged and recurs more frequently. The cows are excited and continually lowing. When in the pasture, they chase their companions and mount them. They bellow for the bull incessantly, and are covered without result. Those which are pregnant may abort ; this latter occurrence is often the first sign of the infection of a stable.

Intestinal and mesenteric tuberculosis give rise to frequent attacks of colic, and profuse diarrhœa alternating with obstinate constipation. Tuberculosis of the liver and its glands is always accompanied by slight meteorism, which comes on after a meal, but does not hinder rumination (Guittard).

Uterine tuberculosis generally shows itself by a purulent discharge, which soils the labia and the commissure of the vulva, and which allows a certain diagnosis to be made either by its microscopic examination or inoculation.

C. **Tuberculosis of the Udder.**—Tubercle of the udder is rare. Out of 100 tuberculous cows, not more than three or four, at the outside, have tuberculosis of the udder (Bang). The lesion betrays itself by a slightly hard, diffuse swelling, unaccompanied by heat or tenderness of the organ. Usually only one quarter is attacked, and by preference a posterior quarter. Sometimes the affected organ is very considerably hypertrophied. For a long time the milk remains normal, but gradually it becomes more and more serous and yellowish. Then it discharges small coagula, which contain bacilli. Finally, but at a much later stage, the secretion becomes purulent, and runs dry altogether. While the milk is undergoing these changes, the lesion of the udder is becoming more marked. Little by little its tissue becomes less supple, and the toughness increases to an almost wooden hardness. At the same time the mammary lymphatic glands become hypertrophied, mammillated, and indurated.

Progress—Duration—Termination.—Tuberculosis is the type of chronic diseases. Its evolution is extremely slow, and may last for years. It is found in animals which have exhibited no derangement of their general health, which have shown no falling off as regards fatten-

ing or the secretion of milk, which have been handed over to the butcher in perfect condition, and which, all the same, are found at the autopsy to be tuberculous in a high degree. It is fairly common to discover tuberculosis, at the abattoir, in the prize beasts of shows of fat cattle. In 1892 the prize beast of the pretty town of Marmande had to be condemned on account of general tuberculosis; it had won 800 francs! Sometimes, after remaining latent for a long time, the disease all at once exhibits paroxysms and more or less lasting exacerbations, which succeed one another at gradually lessening intervals, and end by exhausting the animal. Over-driving, prolonged lactation, food of a bad quality, or some severe intercurrent malady, are the usual causes of these exacerbations.

Finally, when the tuberculosis becomes general, the development of the disease is extremely rapid, galloping, so to speak, as in the acute phthisis of man. The fever is lighted up, never to be extinguished. The animals sink visibly, and succumb, in a few weeks, in a state of marasmus and exhaustion.

Death is the almost certain termination of bovine tuberculosis; but in the large majority of cases the affected animals are fattened as much as possible and handed over to the butcher, before the disease has reached its last stage or death is imminent.

Diagnosis.—The preceding summary is sufficient to show how lacking in precision, and how little characteristic, the symptoms of bovine tuberculosis are. Even in cases where the disease is at a very advanced stage, its recognition is extremely difficult, and the chances of error are very numerous. Much more, then, is it so at the onset of the disease, in animals which retain all the appearances of health.

In late years, however, the diagnosis has become much more easy. To the indications furnished by the clinical examination, it is now possible to add those derived from the histological examination or the inoculation of the pathological products.

More recently still, there has been introduced into science, in the use of tuberculin, a very valuable means of recognising the disease at a time when it is only betrayed by very limited lesions, when there is no external manifestation of it, and when there is no pus, discharge from the nostrils, or any other product, that can be used for inoculation or microscopical examination.

A. **Clinical Diagnosis.**—Tuberculosis of the lung is by far the most common form, whether it exist alone or be accompanied by other lesions. At the outset the diagnosis is almost impossible. One might just guess the existence of the disease from the cough, from the shortness of breath, from the slightly unsatisfactory general state of health, and the wide variations of the temperature. These vague signs only acquire real value when one is dealing with stables in which tuberculous animals are known to have lived, but in all cases prudence will advise the isolation of subjects in which these symptoms are noticed.

Later, the careful examination of the chest sometimes allows one to add, to the signs derived from the general state of health, observations capable of confirming the diagnosis and making it more precise; but it is well to know that this is exceptional. The cough, the bad state of the hair, the adherence of the skin, the tenderness of the region of the kidneys, and the wasting, serve, much more than auscultation and percussion, to establish the clinical diagnosis of tuberculosis. Even in cases where the diagnosis seems obvious, mistakes are

to be feared and, if certainty is our object, other means of diagnosis must be used.

When the disease is localized in the abdominal cavity, the diagnosis is still more difficult. One hardly has anything but probabilities to go upon, derived from the general state of health and derangements of the genital and digestive systems. Such symptoms, too, as meteorism and irregular rumination are more often due to lesions of the mediastinal glands, than to lesions of the liver and the glands in its neighbourhood.

M. Guittard, who has seen a great deal of tuberculosis in cattle, declares that every animal which is frequently troubled with meteorism, unless this meteorism be obviously due to some lesion or common disorder of the digestive tube, must be strongly suspected of being tuberculous. If the meteorism is accompanied by a retarding of rumination, it is very probably due to lesions of the mediastinal glands ; but if, on the other hand, the meteorism is always slight and does not impede rumination, the diagnosis 'abdominal tuberculosis' may be made.

It is sometimes possible to discover hypertrophy of the sublumbar glands or the presence of peritoneal vegetations by means of an examination per rectum or by gliding the hand under the last false ribs.

The diagnosis of tubercle of the uterus or of external glands should always be confirmed by histological examination or inoculation of the vaginal pus and the pulp of the suspected gland respectively.

Pulmonary tuberculosis may be confounded with a certain number of diseases which affect the organs of the thoracic cavity.

Pleuro-pneumonia, in its chronic or subacute form, manifests itself by a group of symptoms which might

suggest tuberculous lesions of the lung. It would be more correct to say that often, at the autopsy of animals slaughtered as pleuro-pneumonic, there is only found tuberculosis of the lung. It is, however, possible in most cases to avoid confounding them. Tuberculosis is more slow in its evolution, and it does not usually provoke fever, or the fever is temporary and not continuous, as it is in pleuro-pneumonia. In pleuro-pneumonia the cough is abortive, hollow, not paroxysmal, and obviously painful, while in tuberculosis it is dry, short, paroxysmal, and when by chance it becomes moist, it is accompanied by a thick and viscid muco-purulent expectoration, which latter is not found in pleuro-pneumonia. Percussion of the thoracic walls is far more painful in pleuro-pneumonia than in tuberculosis. The history of the case ought also to throw light on it, and lastly, in case of doubt, one must search for Koch's bacillus in products which are procurable, or have recourse to the injection of tuberculin. But, if these procedures permit the affirmation of the existence of tuberculosis, it must not be forgotten that the two affections do not exclude one another, and that the tuberculous animal may be also pleuro-pneumonic.

Bronchitis verminosa is common in some countries. It especially attacks lambs and calves, but in some years the adult sheep and cattle are not spared; it is caused by the growth of *Strongylus micrurus* in the bronchial tubes. When it is very abundant the parasite excites respiratory troubles which are disturbing at first sight —for instance, a hard, sonorous, paroxysmal, suffocating cough, with occasionally signs of threatened asphyxia. This cough may be accompanied by expectoration and discharge from the nostrils. Generally the expectorated material is arrested at the pharynx and swallowed. The

discharge from the nostrils, when there is any, is not very thick and is muco-purulent. A feeble magnification shows in this discharge, and especially in the mucus shot forth during the fits of coughing, the worms in different stages of their development, or their eggs. Moreover, there is never any appreciable fever, the appetite is preserved, the coat is glossy; and the animals may be sleek and in good condition, although sometimes they are more or less markedly cachectic.

Echinococci of the lung (hydatid cysts) might also suggest the presence of tuberculous lesions, but a careful examination will enable one to distinguish between the two diseases. When the lungs are stuffed with echinococci, the animals have all the appearances of health; the eye is bright, the skin glossy, and the temperature normal. They may be a little breathless, when exercised, and they may be seized with violent, sometimes almost suffocating, fits of coughing. On auscultation, bronchial râles are often noticed, and sometimes, when a cyst has emptied itself into a bronchus, a most distinct splashing sound. At this period the animal may, in a fit of coughing, expectorate some débris of hydatid membrane, the nature of which can be easily recognised by examination; percussion reveals here and there areas of small extent where the resonance is abolished or diminished, but the dulness is only perceptible where a voluminous cyst has invaded the superficial layers of the lung. If one percusses the thoracic wall with the fist, a peculiar vibration, the hydatid fremitus, may be perceived by the other hand spread out flat

Old hydatid cysts are reduced to the size of a walnut or azel-nut, and consist of a fibrous shell enclosing a more or less thick, mortar-like material of a bright

yellow colour. This is known as the atheromatous degeneration of the hydatid. In a casual examination one might confound these old cysts with small softened tuberculous masses. It is sufficient to dilute the contents with a little water to demonstrate the débris of membrane, which leaves no doubt as to the nature of the lesion.

Actinomycosis may simulate tuberculosis when it infiltrates the lung in the form of small rounded tumours, from the size of a hemp-seed to that of a hazel-nut or walnut, or when it has invaded the tongue or the sub-

presence of actinomycosis.

Œdema and *leukæmia* might be confused with glandular tuberculosis. Even clinically one can distinguish them from it by the symmetrical, regular and progressive hypertrophy of all the explorable glands, by the absence of nodosities, of induration, of calcareous infiltration or central softening. To get out of the difficulty, nothing is easier than to extirpate a gland, to examine it with the naked eye and with the microscope, and to inoculate it. The enumeration of the blood-corpuscles sometimes permits one to diagnose the existence of leukæmia, and thus eliminate all idea of tuberculosis.

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ERRATUM.

Page 41, line 24, for *Œdema* read *Adenia*.

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B. **Bacteriological Diagnosis.**—On all occasions, where possible, the diagnosis ought to be controlled by bacteriological examination of the suspected products—pus, discharge from the nostrils, expectoration, glandular pulp, milk, etc.

If Koch's bacillus is found with its well-defined and peculiar histo-chemical characters, the existence of tuberculosis may be affirmed. In this way, in a few minutes, or half an hour at the outside, a diagnosis can be absolutely confirmed. If the search for the bacillus is fruitless, one is not authorized thereby to deny the existence of the disease; a conclusion is only justified when the result is positive, and if it is negative, the inoculation of the suspected product must be proceeded with.

How are we to procure the virulent product for inoculation or examination? When it is a question of an external ulcerated, tuberculous lesion, or of a suspicious gland, or of a uterine lesion with a purulent vaginal discharge, or of a pulmonary tuberculosis accompanied by discharge from the nostrils, or the expulsion of muco-pus during violent coughing fits, nothing is easier: one has only to make a puncture, or extirpate the gland, or collect the pus, to make the examination or inoculation. When it is a question of the udder, the suspected milk is collected in a large reagent glass of a conical form; it is then covered over and left at rest for twenty-four hours, at the end of which time the bacilli will be deposited at the bottom of the glass; then the 4 or 5 cubic centimetres which occupy the bottom of the glass are drawn up into a pipette and examined, and, if necessary, inoculated.

But these simple cases are not very common. Even when tuberculosis is situated in the lung and the lesions are severe, it is very difficult to procure the mucus

charged with bacilli which the bronchi contain. Fits of coughing have to be very violent to throw the mucus right out of the mouth ; in nine cases out of ten it is arrested in the pharynx and immediately swallowed.

If the tongue be fixed by firm outward traction, deglutition is made impossible ; and if coughing be then excited by pressure on the trachea or larynx, the bronchial muco-pus will be expelled outside, and may be collected in sufficient quantity for examination or inoculation. But it is always very difficult to excite the cough in cattle. How is it to be done, then ? A Dutch veterinarian, Poëls, advises the making at the lower part of the trachea of a small incision for the introduction of a piece of sponge, firmly fixed to the extremity of a long iron wire ; the sponge is pushed towards the bifurcation of the trachea, and becomes impregnated with bronchial mucus, which is then collected, by squeezing the sponge, for examination or inoculation. A single suture in the skin is sufficient to ensure the cicatrization of the wound, and in less than eight days all trace of the operation has disappeared. This is a procedure more simple than it appears at first sight, practical, and free from danger, and gives excellent results.

But cow-owners do not like the performance of an operation of which they exaggerate the gravity and do not understand the importance.

Again, one might be able, with the aid of the sponge firmly fixed at the end of a flexible rod, or between the teeth of a long pair of pressure forceps provided with a catch, to rub the walls of the pharynx of the suspected animal (this is a familiar manœuvre to the practitioner who is used to searching for foreign bodies arrested at the entrance of the œsophagus, and is quite simple) ; the sponge brings back the mucus retained in the follicular

crypts of the mucous membrane, and is then squeezed into a reagent glass, to which a little boiled water is added. In this manner there is obtained a small quantity of material suitable for inoculation or examination. Under my advice, Greffier submitted twelve tuberculous cows to this experiment. In eight of them he was able to affirm the existence of the disease, but in the other four the examination and inoculation only gave negative results.

Lastly, one may have recourse to the subcutaneous injection of veratrine (15 to 20 centigrammes), or else of a salt of pilocarpin (25 to 30 centigrammes). These drugs cause a considerable increase in the secretion from the respiratory mucous membrane, and set up a profuse discharge from the nostrils ; the cough becomes frequent, and the material discharged from the nostrils or expectorated may be used for histological examination, and more especially for inoculation.

C. **Experimental Diagnosis.**—If bacteriological examination does not give positive results, as is most often the case in cattle, inoculation must be proceeded with, and for this inoculation we use the guinea-pig. The guinea-pig is to tuberculosis what the ass is to glanders—the reagent *par excellence*—and when a guinea-pig has withstood a properly-made inoculation, we can assert that the inoculated product did not contain the virus of tuberculosis.

If a pure, or almost pure, product is to be used for the inoculation, such as milk, pus, or the juice of a gland, it is better to inject it directly into the peritoneal cavity, as that is the mode of inoculation which kills the inoculated animal most surely and most quickly ; one may kill such an animal at the end of from fifteen to twenty days, and there will be found at the autopsy tuberculous

lesions, well marked, of the spleen, glands, and great omentum, lesions where Koch's bacillus is swarming.

The milk usually contains few bacilli. A considerable quantity, therefore, must be injected, 1 or 2 cubic centimetres at least, and preferably 4 or 5.

But when there is at one's disposal only an impure product, such as nasal discharge, or muco-pus from the bronchi or vagina, it is better to make the inoculation into the subcutaneous cellular tissue, since these products contain, beside Koch's bacillus, many other organisms, whose proliferation in the peritoneum may set up a rapidly fatal suppurative peritonitis, while under the skin their action is usually limited to the formation of an abscess, which opens externally very quickly, and leaves an ulcer absolutely refractory to cicatrization, the animal in the meantime remaining well, and the evolution of Koch's bacillus being apparently not modified. From the point inoculated this bacillus follows in the guinea-pig a regular and immutable course towards the centre; it first gains the nearest glands, is arrested by them, irritates them, causes their hypertrophy, induration and suppuration; then, the first barrier passed, it marches on, causing the same phenomena, destroying one by one the glands which temporarily arrest its triumphant progress.

In order to observe this regular evolution, the suspected product ought to be injected under the skin of the internal surface of the thigh. The nearest glands are those of the groin and those of the fold of the flank, which latter are quite superficial and easily examined, and the changes which they undergo may be readily followed. One may puncture them to extract the caseous matter which they contain; one may even extirpate them to submit their contents to the Koch-Ehrlich reaction, and

so demonstrate the specific bacilli which are developed in them, sometimes in considerable numbers.

By this procedure one can obtain the certainty, which was lacking, in eight, ten, or twelve days, even more rapidly than if one had inoculated into the peritoneum.

If the bacteriological examination of the extirpated gland gives no result, or if the veterinary surgeon is not provided with the necessary apparatus to practise it, he must wait for the result of the inoculation. This does not mean the death of the subject. He may kill it from twenty-five to thirty days afterwards, and he will find the lymphatic glands, the great omentum, and the spleen, enlarged and crowded with tubercular nodules, and the liver, and more especially the lung, less severely attacked. The diagnosis is thus made certain.

If the inoculation has been made into the ear, the cervical glands are attacked first, then the pharyngeal glands, then the bronchial, and lastly the lung. The lung is infiltrated by thousands of grayish nodules with whitish centres, exactly analogous to those by which the spleen is invaded as the result of inoculation into the thigh.

Of course several guinea-pigs must always be inoculated at the same time, for fear of an accident, which is always possible when an impure product is being used.

The rabbit should only be used for these experiments when a guinea-pig cannot be obtained, since, contrary to what was for a long time believed, the rabbit is an uncertain reagent of tuberculosis—faithless and capricious, so to speak; and in this animal the development of the disease has nothing fixed or regular about it, but seems to depend on individual susceptibility. One subject will take a rapid general tuberculosis as the result of one inoculation with the lancet; in another, the subcutaneous

injection of a very virulent product, in considerable quantity, seems only to give rise to a local tuberculosis with an insidious and very slow progress. In the rabbit, too, the virus does not follow a regular course, as in the guinea-pig. It is, then, only to the guinea-pig that the veterinary surgeon must have recourse if he is anxious to know, with rapidity and certainty, if such and such a suspected product is tuberculous by nature.

D. **Diagnosis by Tuberculin.**—All the methods which we have just discussed are only applicable, of course, to external lesions or to pulmonary lesions, and only to those pulmonary lesions which are already softened and in communication with the bronchi, so that one has a chance of obtaining a virulent product for inoculation. In all other cases, when tuberculosis is confined to the abdominal organs, to serous membranes, or to glands of cavities, all these methods are inapplicable, and until lately the veterinary surgeon remained powerless. He could have suspicions, but he had no means of acquiring certainty. It is not the same to-day: for we have in tuberculin a certain means of making the diagnosis of tuberculosis, even when the lesions are quite recent and very limited.

What, then, is tuberculin?

Everyone remembers, doubtless, the excitement which agitated the entire world towards the end of 1890, on the news that Robert Koch had just discovered a substance, a 'lymph,' capable of preventing the effects of the inoculation of a tuberculous product, of healing a tuberculosis already set up, when not too advanced, and of denouncing the presence of tuberculous lesions inaccessible to other methods of diagnosis. Among the general public, in the medical world even, nothing was thought of but this wonderful event. 'Thanks to the lymph of

Koch the tuberculous were going to be healed !' Thousands of consumptives from all countries, most of them in the last stage, rushed to Berlin, clamouring for injections of the marvellous liquid. Alas ! a change of front was soon necessary, and experience obtained all over the surface of the globe gave the same disappointing results. The 'lymph' appears powerless to heal pulmonary tuberculosis, and, when the lesions are very extensive, it may, in cattle, as in man, cause their generalization, and the development of an acute phthisis rapidly fatal. Several examples of this have been cited. This explains why doctors hesitate to employ tuberculin, even in the very feeble dose which is sufficient to make a diagnosis certain.

On the other hand, experiments made in every laboratory have shown that the 'lymph' of Koch is not more fitted to prevent than it is to cure tuberculosis in the different animals experimented on.

From a purely medical point of view nothing would then remain of Koch's grand discovery, which had raised such great expectations; at any rate, the doctors of man do not appear to be able to derive any special benefit from it. But it is not the same for veterinary surgeons and farmers. Experiments made by thousands, in all countries, have shown that the 'lymph' of Koch, injected in small doses under the skin of cattle suspected of tuberculosis, sets up in the tuberculous animals alone an intense febrile reaction, permitting one to assert the existence of lesions so minute that other methods of diagnosis (clinical or bacteriological examinations and inoculations) would be powerless to reveal their presence, or even to make one suspect their existence.

The 'lymph' of Koch, or, rather, tuberculin, is a simple extract of cultures of the tubercle bacillus in glycerine media.

For a long time Koch kept the method of preparing his 'lymph' a secret. As soon as the lymph could be obtained, it was easy to perceive in it quite clearly the flowery odour peculiar to the culture of the bacillus of tuberculosis in glycerine media. Budjwid at Warsaw, Roux and Metchnikoff at the Pasteur Institute, Hüppe at Prague, each arrived independently at this conclusion, that it certainly consisted of an extract of these cultures, and very soon Roux prepared, from divers specimens of bacilli which he possessed (viz., those of man, horse, pig, pheasant, pigeon, and fowl), tuberculins of an activity at least equal to that of the 'lymph' of Koch. The preparation of them is very simple. A culture in glycerine bouillon, after being left for six weeks in the incubator at 37° to 38° C., is sterilized in the autoclave at 110° C.; it is then concentrated in vacuo in the presence of sulphuric acid, or more simply in a water-bath, till the bulk of the culture is reduced to a tenth part of its original size; it is then filtered and kept in closed vessels, and protected from heat and light. As the bouillon culture contained 5 per cent. of glycerine, the evaporated product contains about 50 per cent., which explains why it retains its activity so long.

Tuberculin is a brownish, syrupy, limpid liquid which possesses, but very feebly, the odour of flowers peculiar to the culture of the bacillus of Koch. When administered through the digestive tract, it produces no effect, but when injected into the veins or under the skin its effects are most remarkable. Into the healthy guinea-pig one can inject as much as 2 cubic centimetres and more without causing it inconvenience; in the case of the tuberculous guinea-pig, on the other hand, $\frac{1}{2}$ cubic centimetre is sufficient to cause death. But if small doses gradually increased are injected, the cicatrization of the tuberculous ulcer at the place of inoculation may be obtained, and a fairly noteworthy delay in the evolution of the visceral lesions, which latter fact caused the belief in the possibility of a cure.

To sum up, the guinea-pig, whose organism is so favourable to the growth of the bacillus of tuberculosis, bears well considerable doses of the products which the bacillus secretes. The same may be said of tuberculous cattle, in which it is extremely rare to notice, after repeated injections of large doses of tuberculin, any noteworthy aggravation of the lesions from which they were suffering. On the other hand, man, who is really rather a bad culture medium for the bacillus, shows an extreme sensibility to its secreted products; whilst the healthy guinea-pig easily stands a dose of 2 cubic centimetres, in a healthy man a dose of even $\frac{1}{20}$ of a cubic centimetre causes serious

symptoms, and in a tuberculous man a few milligrammes may be sufficient to give rise to disturbing symptoms, which are sometimes fatal, hyperpyrexia being the most constant of the phenomena provoked.

The action of the injection of tuberculin on the tuberculous lesions is most remarkable. It is followed, in the immediate neighbourhood of the lesion, by an intense inflammation with exudation, and then abundant infiltration of leucocytes. The tuberculous focus may be thus isolated, cut off, and, as it were, expelled from the tissue in which it has developed. For external lesions, for those of the skin, the result may be advantageous ; but the result may be very troublesome for visceral lesions, the elimination of which is impossible, and which become the focus of new tuberculous growths, and sometimes the starting-point of a rapidly-fatal generalization of the disease.

The numerous researches which I have made with a view to using the injections of tuberculin in the diagnosis of tuberculosis of cattle, and those which have been made abroad by Bang, Lydtin, Jöhne, and Siedamgrotzki, etc., permit me since the end of 1891* to lay down the following propositions :

1. Tuberculin possesses an indisputable specific action on tuberculous cattle, which betrays itself especially by a noteworthy elevation of the temperature.

2. The injection of a strong dose, say 30 to 40 centigrammes, according to the size of the subject, generally causes in tuberculous animals a rise of temperature between one and a half and three degrees.

3. The same dose injected into healthy cattle causes no appreciable febrile action.

4. The febrile reaction appears most frequently between the twelfth and fifteenth hour after injection, sometimes after the ninth hour, very rarely after the eighteenth, and always lasts several hours.

5. The duration and intensity of the reaction have no relation to the number and gravity of the lesions ; it seems, even, that the reaction may be most distinct in cases where, the lesion being very limited, the animal has retained the appearances of health.

6. In very tuberculous subjects, consumptives in the true sense of the word, especially in those which are feverish, the reaction may be little marked, or even absolutely nil.

7. It is wise to take the temperatures of the animals morning and evening for several days before the injection, as one may have to deal with animals who, under the influence of a temporary ailment or

* See *Les Annales de l'Institut Pasteur*, January 25, 1892.

trifling pathological condition, such as disorder of the digestion, present great oscillations of the temperature; hence an important source of error. In the case of these animals it is better to postpone the operation.

8. In certain tuberculous animals which are not feverish, the reaction following the injection of tuberculin hardly exceeds a degree. Therefore as experience shows that, in perfectly healthy animals, the temperature may undergo variations of a degree and more, one must only consider, as having a real diagnostic value, reactions of more than 1·4° C. An elevation of temperature of less than $\frac{8}{10}$ of a degree has no meaning. Every animal whose temperature undergoes an elevation included between $\frac{8}{10}$ of a degree and 1·4 degrees must be considered under suspicion, and will have to undergo, after an interval of a month or so, a new injection of a larger dose of tuberculin.

To these conclusions the following may be added:

(*a*) Successive injections repeated daily, or at intervals of some days, give reactions gradually less intense. There is produced a veritable toleration of the action of the tuberculin. My experiments seem to establish that this toleration is very temporary. In the case of several tuberculous cows submitted to injections every fifteen days, every twelve days, or every eight days, I have registered, eight or ten times running, rises of temperature practically equal.

(*b*) The tuberculous calf reacts just as well as the tuberculous adult; the dose should vary from 10 to 20 centigrammes.

(*c*) The injections of tuberculin have no troublesome effect on the quantity or quality of the milk, or on the progress of gestation. This observation is the result of a considerable number of experiments made on cows in full lactation, and at all periods of gestation.

The value of the indications given by tuberculin has, however, been disputed. It has been said that sometimes it produces no reaction in animals manifestly tuberculous, and that sometimes, again, it sets up the supposed specific reaction in animals which the post-mortem examination shows to be free from tuberculosis.

The first objection has a foundation in fact, but is, nevertheless, unjustifiable. It must not be forgotten that, in highly tuberculous animals, which are phthisical in the true sense of the word, or already feverish, the thermic reaction may be little marked, or even absolutely nil. This is the explanation of the contradictory results at first obtained from the experiments made by veterinary surgeons, for the purpose of finding out what advantage they could obtain from the

'lymph' of Koch. To get along more quickly, and to waste the least possible time, they only experimented on obviously tuberculous animals. Since we know that, to be certain that an animal is tuberculous, the disease must be already far advanced, it follows that many of those animals experimented on must have been absolutely phthisical or feverish. They did not, therefore, react to the tuberculin; but this fact has no importance from a practical point of view, for in such animals there is no need of tuberculin to make the diagnosis, the clinical signs alone being sufficient.

The other complaint against tuberculin would be much more serious, if it was alleged in earnest. Let us see what there is in it: on this point the strongest argument is borrowed from the official report of experiments made at the Imperial Health Office of Berlin under the direction of Schütz.* These experiments were made on a total of sixty-six cattle: fifty-one animals reacted to tuberculin, of which forty-three were tuberculous, and eight had no lesion; of the fifteen which did not react, four were tuberculous.

At first sight these figures are not very encouraging, and justify the reserve adopted on the subject of the value of tuberculin; but when the details of the experiments are examined more closely, we find that Schütz considered as having reacted all the animals whose temperature went up half a degree! Now, it is well known that, even in perfectly healthy animals, a variation in the evening and morning temperatures to the extent of half a degree may sometimes take place, for which reason I only declare tuberculous those animals which undergo, through the action of tuberculin, a rise of temperature of more than 1·4 degrees, so that if my formula is applied to the experiments of Schütz, it will then be seen that, in his hands, two animals alone reacted which were not found to be tuberculous at the autopsy. It is true that the list of tuberculous animals which had not reacted to the injection would be thereby notably increased; but as this increase has reference to animals highly tuberculous, and for the most part regularly phthisical, the considerations explained before will be applicable to them, and the fact loses all its importance. But, it may be said, it is none the less true that, in a small number of non-tuberculous subjects, tuberculin has set up the reaction considered to be characteristic of tuberculosis. Perhaps this has sometimes been the case; but the number of these unfortunate instances

* *Arb. aus d. Kaiserl. Gesundheitsamte, Band VIII.; Annales de l'Institut Pasteur*, Janvier 25, 1892.

is quite inconsiderable, and certainly very much smaller than it appears to be from the published facts. I would like to state that it appears to me extremely probable that if the lesions, which have been proclaimed by the tuberculin, have not been found at the autopsy, it is because in, at any rate, a great number of cases they have not been sufficiently carefully looked for. We must not forget that the duration and intensity of the reaction have no relation to the number and severity of the lesions; it even seems that the reaction may be most distinct in cases where, the lesion being very limited, the animals have retained the appearances of health.* This proposition has been since confirmed on all sides, and I could quote numerous cases, absolutely convincing, where a single tuberculous lymphatic gland or a few small pulmonary foci have been sufficient to cause a reaction of more than 2 degrees.

Jöhne and Siedamgrotzki of Dresden, who have made numerous experiments on this subject,† say with truth that the careful examination of an animal prepared for the butcher's shop can give no certainty of the non-existence of some tuberculous focus situated deeply in a gland or in the marrow of the bones.

All the facts which have been since published in the veterinary journals, as well as before the third congress for the study of tuberculosis, and the International Congress of Hygiene at Buda-Pesth, have entirely confirmed the propositions which I formulated in 1891. Everyone admits to-day the exactitude and marvellous precision of the diagnostic indications furnished by tuberculin. But if the reaction to tuberculin permits the affirmation of the existence of tuberculous lesions, however small, it gives absolutely no useful indication as to the age, extent, and gravity of the lesions.

Etiology and Pathogeny. — Like all the contagious diseases, tuberculosis only acknowledges one cause, namely, the penetration into the system, and the propagation therein, of the specific agent, the bacillus of Koch.

* Fifth conclusion of my *Revue des Annales de l'Inst. Pasteur.*

† *Bericht über des Vétér. in König. Sachsen für* 1890, p. 161.

It is only quite recently that physicians have agreed on this point. However, long before any experiments had been made on this subject, numerous observations had been recorded, which caused many to suspect, and some to affirm, the contagious nature of the affection.

There used to be a widely-spread popular belief in the contagiousness of phthisis, and in some countries the consumptives were isolated (as lepers were in the Middle Ages), and after their death their clothes were burnt, and the houses they had occupied were either burnt or carefully disinfected.

In 1750 the magistrates of Nancy caused to be burnt, in the market-place, the belongings of a woman dead of phthisis because she had lain in the bed of ancther consumptive.

At Naples, a royal decree, dated September 20, 1782, ordered the isolation of consumptives and the disinfection of their habitations, goods, furniture, books, etc., with vinegar, brandy, lemon-juice, sea-water, fumigations, etc., under a penalty of three years at the galleys for common persons, and three years' imprisonment and a fine of 300 ducats for nobles. The doctor who failed to notify a case of consumption was liable to a fine of 300 ducats for the first offence, and to banishment for ten years for the second; and anyone who aided the escape of a consumptive was condemned to six months' imprisonment.

In Spain, too, the popular dread of consumption has existed for a long time. In 1839, Georges Sand, travelling in Spain with Chopin, who was already attacked by the disease which carried him off ten years later, had just settled down in Majorca. 'At the end of a month,' she writes, 'poor Chopin, who had had a cough since we left Paris, became worse; we sent for a doctor—two doctors

—three doctors—each more stupid than the other, who started to spread the news in the island that the sick man was a consumptive in the last stage. As a result, there was great alarm. Phthisis is rare in these climates and is looked upon as contagious. We were regarded as plague-infected, and, furthermore, as heathens, as we did not go to Mass. The owner of the little house which we had rented turned us out brutally, and wished to bring an action against us to compel us to limewash his house, which he said we had infected. The law of the island plucked us like chickens.' At Barcelona fresh tribulations! Just as the travellers were leaving the inn, the landlord demanded that they should pay for the bed on which Chopin had slept, on the pretext that it was infected and that the police regulations required that it should be burnt.*

A letter, dated Rome, November 8, 1803, in which Chateaubriand announced to Fontanes the death of Madame de Beaumont, contains this significant passage: 'I am in a great difficulty; I had hoped to get 2,000 crowns for my carriages, but, by a law of the time of the Goths, phthisis is declared in Rome a contagious disease, and as Madame de Beaumont drove two or three times in my carriages, nobody is willing to buy them.'†

In an interesting communication to the Fifth International Congress held in Paris in 1889, Bang showed how bovine tuberculosis, quite unknown in Denmark in the last century, had been imported into that country, about 1840, by some milch cows coming from Switzerland or the duchy of Sleswig, in which countries it had flourished from time immemorial. Since its introduction it has increased so rapidly that, in 1891, the number of

* 'Correspondence,' 1883, t. ii., pp. 129, 133.

† Sainte-Beuve: 'Chateaubriand et son Groupe sous l'Empire.'

tuberculous cattle at the abattoir of Copenhagen exceeded 16 per cent. of the total number of animals slaughtered.

The powerful and ill-omened influence of Broussais for long caused belief in the spontaneous generation of tubercle. To explain its development all the common causes, so frequently met with in old books on pathology, were invoked—such as dampness, chills, insanitary and ill-ventilated habitations, overcrowding, exhausting work, prolonged lactation, insufficient food; in fact, to use the expression of Bouchardat, 'physiological want.'

All these causes may assist in the development of tuberculosis; they are powerless to create it.

It was in 1865 that Dr. Villemin, Professor at Val-de-Grâce, made known to the Academy of Medicine the result of his researches. In a considerable number of experiments he had succeeded in inducing tuberculosis of rabbits, guinea-pigs, and even dogs, by inoculations of tuberculous matter and phthisical sputa, under the skin, into the peritoneal cavity, and into the trachea.

The researches of Villemin, so important, so conclusive, and, one might say, so glorious for French science, were vigorously fought over. His opponents said that the animals experimented on belonged to species very prone to spontaneous tuberculosis; and, further, that, as the injection of ordinary (?) pus or inert foreign bodies sometimes gave rise to the formation of inflammatory nodules or small multiple abscesses, resembling tubercular nodules, they refused to believe in the transmission of phthisis, and regarded the tubercular nodules obtained by Villemin as a series of small foci due to the action of the inflammation-producing material inoculated. It was in vain that Villemin retaliated by showing that these nodules, of which they denied the specific nature,

could be reinoculated indefinitely from animal to animal; it was in vain that Chauveau made calves tuberculous by feeding them on tuberculous products; the large majority of physicians refused to allow the contagious nature of the affection.

The opposition only ceased on the day when Koch showed that the inoculation of the bacillus, isolated in a state of purity by successive cultures, produced a tuberculosis identical with that produced by the inoculation of tuberculous sputum or any other tuberculous products.

Pathological anatomy and experiments show that the respiratory and digestive systems are the principal gates of entry for Koch's bacillus.

The nasal discharge or the mucus expectorated during fits of coughing are the ordinary agents of infection, and find their way into the system of the healthy neighbours of the affected animals, either by infecting their food or, after drying, by mixing with the air they breathe under the form of dust. Experiments show the very great importance of this last method of infection.

Wherever the bacilli are arrested, they soon excite the formation of granulations, of miliary tubercular nodules, which increase in size and in number, and coalesce to form more or less bulky mammillated, irregular masses. The lymphatic glands, which collect the lymph from the region affected, participate in the lesion and become infiltrated by granulations, miliary nodules and caseous material; it is always the nearest gland which is attacked first, and the disease appears to be appreciably stopped on its invading march when it reaches it. The lymphatic gland plays the part of a barrier, which the bacillus only succeeds in passing when the gland has been almost entirely destroyed; it next attacks a second gland, then a third, and then in succession all the links of the chain

which connect the organ primarily inoculated with the central system (Colin).

It happens sometimes that the organ which has allowed the bacillus to enter—say the lung, pharynx, or intestine—shows no apparent lesion, and the disease attacks at the first onset the glands—bronchial, pharyngeal, or mesenteric.

Primarily, then, tuberculosis is a local disease, which has developed in the organ first penetrated by the bacillus. It remains local, in spite of the increase in number and importance of the foci of disease, as long as the bacilli, on their onward march, have not gained access to the blood-stream. Only when that has happened can one say that the disease has become general in the true sense of the word.

The multiplicity of the organs invaded, even when these organs belong to different systems or different visceral cavities, does not necessarily imply the generalization of the disease. It may spread, and it usually does, in other ways—by following the lymphatics, for instance, in the manner indicated above, the nearest glands being the first attacked; from the glands the tuberculosis may reach the adjoining serous membranes; from the peritoneum it may spread to the pleura, without the mediation of the bloodvessels, by means of the lymph-spaces which traverse the diaphragm. On the other hand, uterine tuberculosis may gain the peritoneum by way of the Fallopian tube, and *vice versâ*. The intestine and mesenteric glands, and then the liver, are often infected by bronchial mucus, coughed up into the pharynx and then swallowed. The ulcers of the mucous membrane of the bronchi, trachea, and larynx may be due to broken-down portions of the lung which have been discharged into the bronchi.

In all these cases, one cannot say that the disease is generalized. They are successive localizations, multiple, and perhaps numerous and important; but tuberculosis is only generalized when the bacilli have been disseminated throughout the whole organism by the blood-vessels. This takes place when, all the glands in the chain having been successively destroyed, the lymph carries the bacilli into the thoracic duct, whence they are poured into the anterior vena cava; or, again, when a tubercular focus perforates the wall of a vein of a certain size, and pours into it the virulent material which it contains.

Tuberculosis then assumes the character of a general disease; the blood and all the vascular tissues are virulent, and the tissues which are favourable to the growth of the bacillus, notably the liver, the spleen,* and the marrow of the bones, become the seat of a considerable number of specific granulations, all of the same size and age, which constitute what is known in human medicine as 'granulie' or 'acute miliary tuberculosis.'

The lung and the intestine—the lung especially—are the great roads of entry for the bacillus. They are not the only ones. Cases of infection by the bull during coition have been described, and recorded instances of tuberculosis localized in the uterus go to confirm the possibility of the fact.

I am not aware of any authentic records of direct inoculation by the skin, from animal to animal; but the great resistance of the bacillus to causes of destruction renders a very mediate transmission possible; and it is quite credible that a deep wound on an animal might

* In cattle, the presence of miliary tubercle in the tissue of the spleen is the best sign of the generalization of tuberculosis (Ostertag).

become inoculated by contact with soil or litter impregnated with virulent matter.

It is, moreover, only by such means that we can explain the known cases of primary tuberculosis of the udder. Lydtin has recorded the case of a cow accidentally inoculated in the tail by virus from a lung which was both pleuro-pneumonic and tuberculous. The necessity for the entrance of the bacillus being admitted, let us consider what the conditions are which favour its entry into the organism and its growth there, and its propagation and perpetuation in an infected stable.

All the causes belonging to the individual—constitution, temperament, age, work, food, and prolonged lactation—may act as predisposing conditions; they may favour the propagation of the bacillus, and the early generalization of the lesions, by weakening the resistance of the organism.

The mode of keeping the animals plays the most important part in the propagation of the disease; permanent stabling, continued for a long time, in badly-kept, ill-ventilated stalls at a high temperature favours the development of the disease, owing, no doubt, to insufficient action of the respiratory apparatus and the very close intercourse in which the animals live.

Formerly it used to be looked upon as an axiom that the milch cows of large towns were almost certainly doomed to phthisis, and, as a matter of fact, most of the cows of Paris delivered over to the abattoir were there recognised to be tuberculous.

At the present time, nothing is more difficult than to find a tuberculous cow in the stalls of the cow-keepers of Paris. To what is this radical change due? Certainly sanitary regulations have nothing to do with it, for

tuberculosis has only been legally registered as an epizoötic since 1888. The cause of the gradual disappearance of the evil is simply this, that the economic conditions of the production of milk in the large towns are absolutely different from what they used to be.

At the present time, the cow-keepers of Paris do not have their cows put to the bull; they buy them just after they have calved, in full lactation, and they keep them always well fattened, and deliver them over to the butcher directly they cease to give enough milk, the result being that the cows seldom stay more than a year in their stables. During this short stay, the animals which had in them the germ of tuberculosis when bought, have hardly time to infect the others, and if they do succeed in infecting their next-door neighbours, the lesions so set up remain very limited, and have not time to undergo the softening which would render them, in their turn, dangerous. A few years ago, on the other hand, a cow-keeper kept his cows as long as he could expect, by means of a new pregnancy, to get a continuation of the secretion of milk; so each cow used to remain in the stable for four, five, or six years, and if one of them was tuberculous, it had plenty of time to infect its neighbours and the entire stable. These conditions, so favourable to the spread of the disease, are still the conditions of most of the stables in country districts; so that when one has been unfortunate enough to introduce into one of these stables a tuberculous cow, and the animal has remained there some time, it may be said that the stable is henceforth infected, the contagion has taken up its abode there, and that, with very few exceptions, all the other cows will be seized one after the other.

And this rule applies even to the best-kept stables. I could instance a large number in which tuberculin has

allowed me to assert that 40, 60, 80 per cent., and more, of the herd were affected.

The power which tuberculosis possesses of spreading is not sufficiently known. There are some countries, among the most advanced in breeding, rearing, and animal hygiene, where the number of the tuberculous cattle is more than 20 per cent. of the total bovine population.

In Saxony, for instance, the official statistics of the abattoirs under inspection show that the number of animals recognised as tuberculous was in 1891 17·4 per cent.; in 1892, 17·79 per cent.; in 1893, 18·26 per cent., while in some towns the proportion approached 30 per cent.

At the Copenhagen abattoir the proportion of tuberculous animals in 1891 reached 16·60 per cent.

Out of 125,000 cattle slaughtered at Berlin in 1891, almost 15,000 were tuberculous, or 12 per cent. 'But,' says Ostertag, 'the number affected would be much higher if all the slaughtered animals were thoroughly examined. . . . One day I examined, in this manner, forty-three fat beasts: twenty-one had tuberculosis of the bronchial glands.'*

In England, the inspection of abattoirs is still in a rudimentary state; it is, however, from that country that we get the most valuable statistics. It is well known what admirable energy the English have expended in order to stamp out contagious pleuro-pneumonia. Their Act of 1890 orders the slaughter, not only of the sick and suspected, but also of all the animals that have been in contact with the sick. In 1891 there were thus slaughtered, in different parts of England and Scotland, nearly 10,000 animals (of which only 800 were sick);

* *Zeitsc. f. Hyg.*, July, 1891.

post-mortems were made on these 10,000 animals, and 1,260 were tuberculous, or 12½ per cent.

In 1892 the operation was continued, but was brought to bear on much smaller numbers, pleuro-pneumonia being on the decrease. However, there were slaughtered 3,600 animals (of which 134 were sick), and of this number nearly 800 were tuberculous, or 22 per cent. This high proportion is due to the fact that the slaughtering operations were brought to bear on some of the most crowded and anciently infected cow-houses in London, some of which had as many as 50, 60, and 70 per cent. of their cows tuberculous.

In France we have not sufficient data to estimate, even approximately, the number of tuberculous animals. We know that some districts are almost free from it—for instance, Auvergne, Limousin, and the greater part of Normandy; while in others, such as Champagne, Bretagne, Nivernais, and Béarn, the disease makes considerable ravages. Beauce and Brie are infected to such a degree that the losses due to tuberculosis will soon exceed those that used to be caused by splenic fever before Pasteur's vaccination was put in practice; the most experienced veterinary surgeons estimate that the number of tuberculous animals in these places exceeds 25 per cent. of the total strength.

An insurance society at Eure-et-Loir has had to pay, from 1888 to 1891, for 360 cows dead of divers diseases, of which 53, or 15 per cent., had died of tuberculosis; and then it must be remembered that, usually, the death of the animal is not waited for, but it is taken to the abattoir or nearest slaughter-house as soon as it begins to pine away.

At the abattoir of Toulouse in 1889, 1,254 animals out of 13,507 were found to be tuberculous. As the

inspector strictly applied the terms of the decree of July 28, 1888, the number of tuberculous animals fell in 1890 to 340 out of 12,694 slaughtered, about a quarter of the number of the preceding year! The surplus had been turned on to private slaughter-houses not under inspection.

The introduction of a tuberculous animal is the necessary condition for the infection of a farm hitherto healthy. Is that condition enough? No. The contagion of tuberculosis is of a particular kind, and is not comparable, by a long way, to that of aphthous fever, scab, rouget, or pneumo-enteritis of the pig. In case of these diseases, the least contact with a sick animal, or objects which it has infected, is enough to ensure the transmission of the malady; in the case of tuberculosis, transmission only takes place as the result of an intimate and prolonged cohabitation.

The sojourn in a common pasture may be looked upon as practically free from danger. There is little risk of infection at a distance through the air, even at a short distance. I have several times seen the cows of one stable remain healthy, when in an adjoining stable, in free communication with the first by a door or an open window, most of the animals were tuberculous, some absolutely phthisical. I have often seen the disease attack all, or nearly all, the cows of one range of the infected stable, while the other range remained healthy. More often, again, in stables where 70 to 80 per cent. of the cows were contaminated, I have found the bull healthy; either it was a young animal recently introduced into the stable, or else an obstreperous subject, which had been relegated to one corner of the stable, with a gap of one or two empty stalls between it and the nearest cows, this very comparative isolation having been suffi-

cient to keep it free from infection. The influence of climate, of occupation, even of race, is almost nothing; the sole thing really to be afraid of is the prolonged sojourn of healthy animals in a stable, even though it be well kept, in the immediate neighbourhood of an affected beast, especially when that beast has a cough and scatters around it virulent mucus teeming with the bacilli of Koch.

Heredity.—By the public, by physicians even, tuberculosis is still looked upon as the type of hereditary diseases. We have ceased to reckon up the observations with reference to families the majority of whose members die of tuberculosis, one after the other. Are we to say that the ancestors transmit with a fatal precision to their descendants the germ of the disease by which they themselves have been attacked? Ought we not rather to invoke, in explanation, the numberless opportunities for infection to which the child of a tuberculous mother is exposed from the day of its birth onwards? The suckling, the kisses, the intimate and continual cohabitation, do they not play a principal part in the perpetuation of the disease in the bosom of the family?

The conditions of social life complicate this important question too much for doctors to be able to answer it by clinical observation alone. Veterinary surgeons are in a better position to decide the question than they, for a considerable number of calves only a few weeks old are slaughtered in the abattoirs, and by comparing the number of the calves with the number of the cows which are found to be tuberculous at the autopsy, a fairly distinct idea of the part which heredity plays in the development of bovine tuberculosis can be formed.

The most moderate estimates of abattoirs, in districts where tuberculosis is most rare, put the number of tuber-

culous cows at 2 or 3 per cent. Most statistics are silent on the subject of the calves; all inspectors agree that nothing is more rare than tuberculosis of the calf. Here are some figures demonstrating this point: At the abattoir of Munich 160,000 calves are slaughtered yearly on an average, and out of this number there have been found tuberculous—2 in 1878; 1 in 1879; 0 in 1880; 0 in 1881; 2 in 1882.

At Lyons, M. Leclerc, who has taken a particular interest in this question, has only found 5 tuberculous calves out of more than 400,000 slaughtered at the abattoir.

At Rouen, Veysièrre has found 3 out of 60,000.

At Berlin, Jöhne has found 4 out of more than 150,000.

In 1887, Ostertag found 6 out of 87,685, or less than ·007 per cent.

At Augsburg the proportion of tuberculous adults was 3·62 per cent. in 1887, and 3·95 per cent. in 1888; of tuberculous calves was ·013 per cent. in 1887, while in 1888 not a single tuberculous calf was found.

In Prussia, from April 1, 1892, to March 31, 1893, there were slaughtered in the public abattoirs 600,501 adult cattle, of which 52,136 were tuberculous, or 8·68 per cent., and 914,216 calves, of which only 446 were tuberculous, or a little less than ·04 per cent.

Saxony is perhaps the most seriously infected country in the whole of Europe; in 1890, in all the abattoirs of the kingdom, 16·5 per cent. of the cattle slaughtered were tuberculous, and ·04 per cent. of the calves (33 out of 85,000); in 1891, 17·4 per cent. of the cattle, and ·06 per cent. of the calves; in 1892, 17·78 per cent. of the cattle, and ·11 per cent. of the calves; in 1893, 18·26 per cent. of the cattle, and ·12 per cent. of the calves.

To thoroughly appreciate the value of these figures, it must not be forgotten that everywhere the number of tuberculous cows is infinitely greater than that of other cattle. At Copenhagen, in 1888, the statistics gave a proportion of 6 per cent. for cattle of all ages, and 16 per cent. for cows. 'The number of tuberculous calves is always very small, and there, where so many of them are consumed, the general average is always very low' (Bang).

Again, we must take into consideration the fact that calves are not handed over to the butcher before they are twenty days old, and most of them not before they are six weeks or two months old; thus, it may quite well happen that some of those found to be tuberculous when slaughtered, may have been contaminated by a sojourn in infected surroundings or by being fed on a virulent milk.

Also, in most of the cases quoted, the examination has been confined to the macroscopic determination of the nodules, and has not been confirmed by the bacterial diagnosis, and it is quite possible that in a certain number of cases, especially those of lung nodules, the examiners had to deal with lesions caused by parasites; *Strongylus micrurus*, so common in the calf, causes in it nodules which it is impossible to distinguish by the naked-eye appearances from true tubercle.

There are, however, recorded examples where the congenital origin of the tuberculosis cannot be disputed.* Jöhne, Malvoz, and Brouwier, and Czokor, notably, have published, with regard to this, observations which are now classical: they were cases either of fœtuses almost at term found in the uterus of tuberculous cows slaugh-

* Bang has seen twenty-eight cases of tuberculosis in the fœtal or newly-born calf.—H. S.

tered for the butcher, or else of calves still-born or slaughtered a few days after birth; in all these cases the tuberculous lesions, situated in the liver and neighbouring glands (which shows that the infection had followed the course of the umbilical vessels), contained the bacillus of Koch.

It is clear that, in a case of general tuberculosis in a pregnant cow, the gravid uterus, the placenta, and consequently the fœtus, may be attacked, in the same way as all the tissues of the mother (abortion is, moreover, the most frequent result of this); nevertheless, the statistics which we have just quoted prove that, in cattle at any rate, true generalization of tuberculosis is a rare thing.

On the other side, as calves are slaughtered for the butcher at an early age—the earliest, according to regulations, being three weeks; the usual, six to eight weeks—the objection might be put forward (as was done by Dr. Empis at the last congress for the study of tuberculosis) that such and such subjects, pronounced healthy at the abattoir, might nevertheless have microscopic tuberculous lesions of the organs; or that the calf, born of a tuberculous mother, and having received from her the germs of the disease, might preserve all the appearance of health, both clinical and post-mortem, the germs being in a latent state—gone to sleep in some way for a variable time, only to awake at a later period to effect their evolution and betray their presence by the classical lesions of tuberculosis.

This objection it is easy for me to answer, by bringing up against it a large number of observations which I have collected on journeys through the country, made during the last few years for the purpose of popularizing the use of tuberculin.

In stables where tuberculosis has existed for several

years, the proportion of tuberculous animals is always considerable, and may be as high as 50, 60, or 80 per cent. of the total herd. The adults always furnish the largest contingent of the affected animals, and especially the adults which have been a long time in the stable. The young animals, on the other hand, are almost all spared. In places where, out of ten adults, eight or nine are tuberculous, out of ten young animals, even if born of tuberculous mothers, seven, eight, or nine escape the infection. And when I speak of young animals, I mean no longer calves six weeks old, as they are slaughtered in the abattoirs, but animals aged from six to twelve or fifteen months. This is not early infancy for cattle.

But I have more evidence: In October, 1892, I had occasion to test with tuberculin all the animals on a large and fine farm in the North of France: 55 out of 105 were tuberculous—46 out of 57 adults; 9 out of 42 aged from four months to two years. Twenty months later I repeated the test on 30 of the young animals which had escaped infection, and on 14 more which had been born since the first trial. Of this number 25 were born of tuberculous mothers. Not one of these animals gave the slightest reaction—not one had become tuberculous; and most of them are now two, two and a half, three, and more years old.

After the first trial, all the healthy animals had been strictly isolated from the affected ones.

Do not these facts show the very feeble part which heredity takes in the propagation of bovine tuberculosis?

Experiments have been made to demonstrate the transmissibility of tuberculosis from the mother to the fœtus.

According to MM. Landouzy and Martin, the tuberculous mother will transmit to its young, not only the

predisposition, but also the germs itself, which may not develop till a long time after birth; they claim to have rendered tuberculous guinea-pigs into whose peritoneal cavities they had inoculated pieces of organs (lung and liver) which were healthy in appearance, but were taken from two human fœtuses and one guinea-pig fœtus born of tuberculous mothers.

These experiments have been repeated by a great number of investigators (Leyden, Grancher, Nocard, Straus, Sanchez-Toledo, Vignal, etc.), and in their hands gave only negative results. Galtier, however, succeeded, in a very small minority of cases, in transmitting tuberculosis by the inoculation of the organs of fœtuses born of tuberculous mothers.

As for Robert Koch, whose authority in the matter is undeniable, he declares positively that he has never seen his female guinea-pigs, when tuberculous, transmit the disease to their offspring. According to him: 'Hereditary tuberculosis finds its most natural explanation, if one admits, that it is not the infectious germ which is transmitted, but certain peculiarities which are favourable to the development of this germ when afterwards brought into contact with the body. This we call the predisposition.'

To sum up: If it is true that the bacillus of Koch may sometimes pass from mother to fœtus, it is none the less true that this passage is an absolutely exceptional thing. What the mother does transmit to her offspring is not the disease itself, but the predisposition or proneness to contract the disease. In other words, the offspring is born tuberculizable, not tuberculous.

The opposite doctrine, so generally admitted, may have the most funereal consequences; it conduces to the fatalistic resignation of the Orientals. 'What good to

struggle against it, if the tuberculous mother transmits to her child with fatal certainty the germ of the disease? Do what one may, sooner or later the seed will germinate! At the most, one will have managed to put off the evil day!'

How reassuring, on the other hand, is the notion that hereditary tuberculosis is an exceptional thing; that, far from being condemned to tuberculosis, the child of the tuberculous may easily escape it, and will do so, if it is removed from the family surroundings, in which are realized such a combination of conditions favourable to the occurrence of infection that it is hard to understand how it could possibly escape!

This is not pure speculation. I could name at this moment a dozen fine children, aged from five to ten years, which, put out to nurse in the country soon after their birth, have escaped the hereditary (?) tuberculosis to which one or several of their elder brothers had succumbed.

Dr. Hugo of Laon, in the course of his long experience, has collected several observations of a different kind, which plead in the same way. He has several times seen women, who had been for a long time tuberculous, and had already lost several children from meningeal or mesenteric tuberculosis, bring to a successful conclusion a last pregnancy and then die of galloping consumption some weeks or months after their confinement. To his surprise, the infant, necessarily put out to nurse, became a fine child and escaped the infection; it appeared to be more threatened than its elder brothers and sisters, but the death of the mother accomplished the isolation and saved the infant from the disease.

If one confines one's self to the consideration of the breeding of cattle, one sees that the doctrine of hereditary

tuberculosis is none the less funereal in its effects. How often have I seen the owner of an infected stable ready to give up breeding because most of his finest cows were contaminated! I have had the greatest difficulty in convincing him that in a few years, without great expense, he would be able to reconstitute his stock, thanks to the young animals, who had mostly escaped the infection. Everywhere where I have applied the injection of tuberculin, I have affirmed in the most positive manner that the young animals proved to be healthy would remain healthy, on the sole condition of their being isolated from their tuberculous mothers and from every other infected animal; and everywhere my prognostications have been realized.

Resistance of the Bacillus to Causes of Destruction—Action of Antiseptics.—Tuberculous products retain their virulence for a very long time, especially when they are dried. Boiling water instantly sterilizes sputum and pus; but when these products have become dry, they resist immersion in boiling water, and the boiling must be prolonged for fifteen, twenty or thirty minutes to sterilize them with certainty.

That is why the expulsion of sputa or muco-pus from the bronchi, during the coughing fits of animals suffering from pulmonary tuberculosis is so dangerous. These materials, rapidly dried in thin layers, retain their virulence for months, and sometimes years; they also resist for several months putrefaction, immersion in spring or river water, and freezing. The resistance of the infected material against all these conditions is considerably increased when it has been previously dried.

The extremely well-conducted experiments of Bang have established the fact that the bacilli of tuberculous milk are destroyed with certainty when the milk is heated

to 85° C. for five minutes; between 75° and 80° they are sometimes killed, but not always; they resist a temperature of 70°, and are afterwards able to render guinea-pigs and rabbits tuberculous, when inoculated into the peritoneum; but their vitality is lowered, and they are no longer able to resist the action of the digestive juices of the same animals. At 60° their virulence does not seem to be modified. Galtier has obtained results almost identical with those of Bang.

Sunlight has an energetic destructive action on the bacilli, in direct proportion to the intensity of the rays, and in inverse proportion to the thickness of the material exposed to it (Koch).

Salting and smoking have no effect on the virus (Förster).

Sulphurous acid is a good disinfecting agent; after twenty-four hours' exposure to sulphurous fumes produced by the combustion of 40 to 60 grammes of sulphur per cubic metre, the bacillus of Koch was destroyed, even in what appears to be its most resistant state, in the sputum (Vallin, Thoinot).

Carbolic acid, creoline and lysol in a 4 per cent. solution, and corrosive sublimate in an acid 1 per mille solution, are good disinfectants; but if the tuberculous material has become dry it is prudent to prolong the exposure to the liquid disinfectant. The antiseptic action of these liquids is considerably increased if they are heated when used.

Experimental Transmission of Tuberculosis, and the Different Methods of Inoculation.—We have seen above that the guinea-pig is the subject *par excellence* for the experimental inoculation of tuberculosis; in it the inoculation of a particle of a tuberculous product causes with certainty the evolution of a tuberculosis, which inevitably

ends with death after a period of time varying from three weeks to two or three months.

It is as the result of the *intraperitoneal injection* that the infection progresses most quickly: the animal is seen to grow perceptibly thinner; sometimes it is possible to perceive, through the abdominal walls, the swollen, hard and nodulated spleen, or the great omentum transformed into an indurated and mammillated, pudding-like mass; death always supervenes very rapidly, and if the animal be slaughtered after fifteen or twenty days, tuberculous lesions of the spleen, liver or great omentum will certainly be found. The lesions of the spleen are absolutely characteristic, and were well described by Villemin in his first publications; they are always the same, whatever be the origin of the inoculated product, whether it has been taken from man or any other animal except birds. The spleen is always enormously swollen in every direction; to begin with, it is always infiltrated by a considerable number of minute tuberculous granules; later, it presents a surface, as it were, marbled: on the dull red background of the tissue of the organ, yellowish veins, where the substance has undergone vitreous and then caseous degeneration, design veritable arabesques of curious and asymmetrical shape. If death has been long delayed, the liver shows similar changes, but always less marked than those of the spleen; it has a nodose surface traversed by yellowish, irregularly-shaped veins, or else its tissue is more or less distinctly cirrhosed.

The *injection into the subcutaneous cellular tissue* gives, in the guinea-pig, results almost as certain, but less rapid than those of intraperitoneal injection; it is especially indicated in the case of an impure product contaminated by germs, the development of which in the peritoneum

might set up a suppurative inflammation or a rapidly-fatal septicæmia.

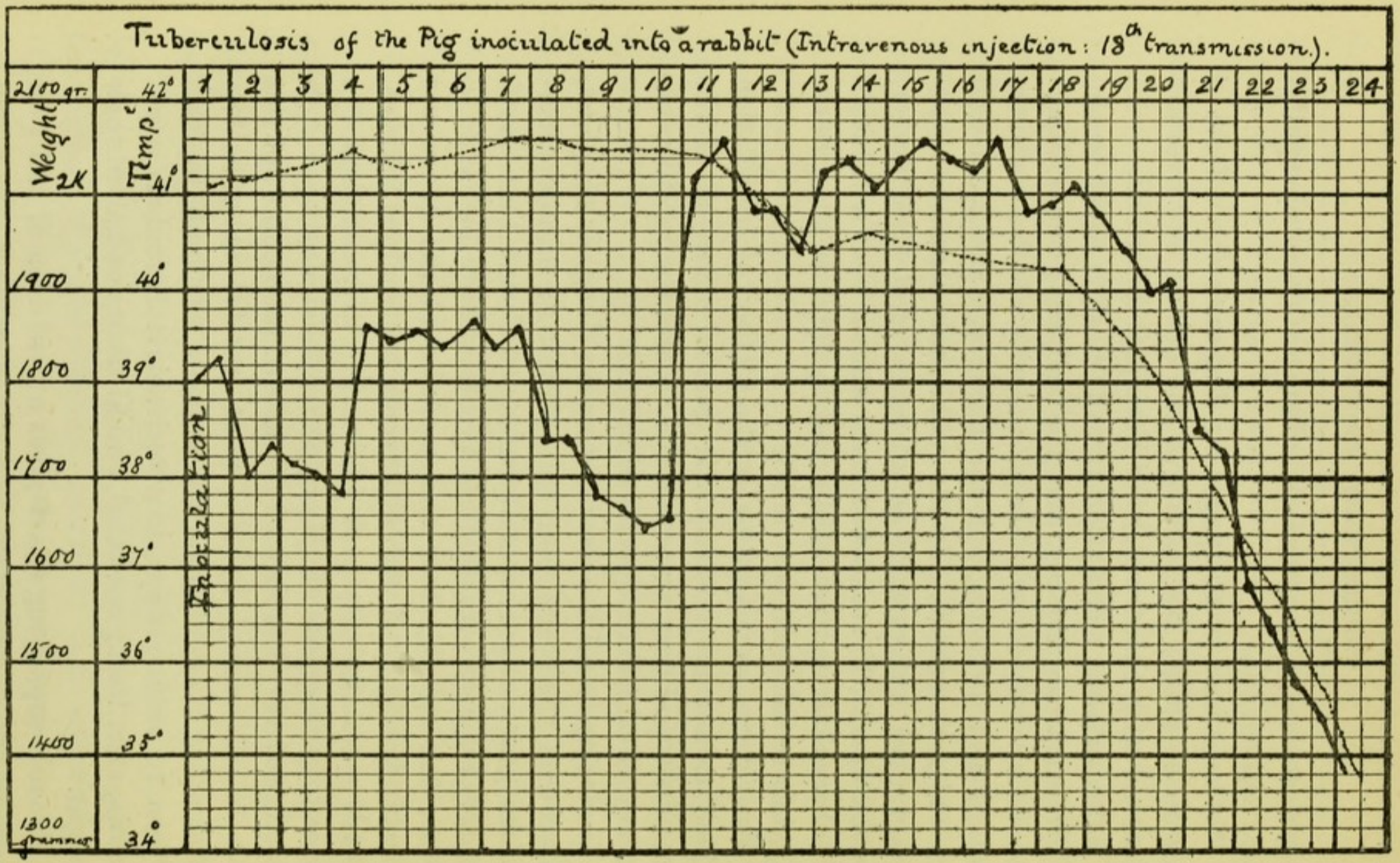
We have seen in the pages on diagnosis the effects of this inoculation; the lesions of the spleen and liver are identical with those which we have just described.

Subcutaneous inoculation usually has no effect on the adult carnivora, the pig, and the solipeds; there supervenes a more or less voluminous nodosity which sometimes softens and ulcerates, but the lesion remains local, and gradually disappears. In the rabbit, subcutaneous inoculation does not succeed in all cases, and Hischberger, Gebhardt and Vyssokowicz have shown that a dilution of tuberculous sputum, still certainly fatal to the guinea-pig, has no effect on the rabbit.

The *intravenous injection* is the method of inoculation which causes most surely the general infection of the organism, and may overcome the sometimes considerable resistance of certain species of animals.

It sets up in all the vascular organs (lung, liver, spleen, marrow of the bones, etc.) an eruption of minute tuberculous granulations, sometimes so confluent that death supervenes before anatomical tubercles have had time to form; the spleen, liver and medulla of the bones are absolutely crammed with embryonic tuberculous follicles, which are extremely rich in bacilli; to the naked eye these organs appear simply hypertrophied, engorged with blood, and very friable, and no trace of tubercular nodules can be discovered by the most careful examination. After a few transmissions the animals succumb, in from fifteen to twenty days, to a veritable tuberculous septicæmia, after losing one-third, two-fifths or one-half of their weight.

The accompanying chart gives a good idea of the progress of the temperature and the wasting in a rabbit



Temperature: ——— Weight: .....

inoculated in the vein of the ear. On the tenth day after inoculation the temperature suddenly rose above 41°, remained so for seven or eight days, and then fell rapidly below normal.

The weight began to diminish directly after the onset of the fever, and the daily decrease had become considerable by the time the temperature had begun to fall.

Inoculation into the anterior chamber of the eye, introduced by Cohnheim, is another very interesting method, and succeeds equally well with both guinea-pig and rabbit. It is followed by a mild keratitis, which disappears promptly, and afterwards, from the fifteenth to the twentieth day, the iris is seen to be covered with fine tuberculous granulations; then, at the same time as the eye is swollen and troubled in a definite manner (it frequently undergoes purulent softening, and always becomes atrophied), the parotid lymphatic glands become hypertrophied and indurated; then, in order, the pharyngeal, inferior cervical, bronchial, etc., glands, and, finally, the animal dies with pronounced tuberculous lesions of the lungs.

The *sub-epidermic inoculation* by means of pricks or scratches is never effectual. M. Chauveau has never succeeded in infecting the calf by this method. The small lumps which sometimes form at the site of the scratches quickly disappear and leave no trace. M. Colin has published the case of a rabbit which, after inoculation with a lancet, succumbed to an extremely confluent general tuberculosis; but the skin of the rabbit is so thin that the lancet had doubtless pierced it, and deposited some of the virus in the subjacent cellular tissue.

The *inhalation* of tuberculous material, when it has been dried and reduced to a powder, is the most certain method of setting up a pulmonary tuberculosis identical

with the natural disease, and is successful in most animals. Villemin, Tappeiner, Koch, and Thaon have often tried this experiment; but it is a dangerous proceeding for the experimenter, and it was in this way that Thaon contracted tubercular broncho-pneumonia, which proved rapidly fatal.

Ingestion of tuberculous material may also produce tuberculosis. The experiments of Gerlach, Günther, Harms, and more particularly those of Chauveau (1868), have put this fact beyond the region of doubt. By adding to the drinking-water of young cattle tuberculous pus or carefully-diluted caseous material, one gives them, to a dead certainty, tuberculosis of the organs of the abdominal cavity. These facts have been everywhere confirmed since, notably by Saint-Cyr for cattle, by Toussaint and Peuch for pigs, by Leisering for sheep, by Böllinger for goats, by Viseur for cats, and by Jöhne for most of the different species.

An important thing to note is, that the younger the animal operated on, and the greater the quantity of virulent material ingested, the better the experiment succeeds. The guinea-pig even resists the ingestion of minute quantities of virulent material, when a much smaller quantity of the same material inoculated under its skin will give it tuberculosis to a certainty.

All tuberculous products, whether pus, sputum, caseous material, fibrous or calcified miliary nodules, are equally capable of giving tuberculosis by ingestion; it is the same for milk from a tuberculous udder, as to which fact the experiments of Gerlach, Klebs, Böllinger, Peuch, Bang, etc., leave no doubt whatever.

But although tuberculosis can be transmitted through the digestive tract, it does not follow that it is a method as sure and as certainly reliable as inhalation, and, above

all, injection into the cellular tissue, peritoneal cavity, or veins. Far from it. Ingestion only succeeds in giving tuberculosis when the ingested material is very rich in bacilli.

A young pig was able to drink with impunity 4½ litres of a tuberculous milk, a few cubic centimetres of which injected into the peritoneal cavity of a rabbit killed it in a few weeks (Peuch).

Highly-tuberculous milk, heated for five minutes at 70°, still kills with certainty rabbits and guinea-pigs, when inoculated under the skin or into the peritoneal cavity, but can be drunk in considerable quantities without any danger by animals of the same species (Bang).

The researches of Böllinger and Gebhardt show that the dilution of tuberculous material greatly diminishes its infectivity; for instance, if the milk of a tuberculous cow is given as the principal or sole nourishment to certain animals, such as guinea-pigs, rabbits, and cats, all those which take it become tuberculous; but if it is given to them diluted in 50 or 100 times its bulk of normal milk, they may consume the mixture for entire weeks with impunity.

In the case of the guinea-pig, tuberculous sputum diluted 100,000 times may still set up tuberculosis, when 1 cubic centimetre of the dilution is injected into the peritoneal cavity or under the skin; but if the animal is made to swallow 2 cubic centimetres of the sputum diluted in ten times its bulk of water, it does not always die. The experiments just given are very important when we come to deal with the question of meat inspection and tuberculous milk.

Identity of Tuberculosis of Man and that of Animals.—Everyone admits to-day the identity of tuberculosis of

man and that of the mammalia. There is only doubt with reference to tuberculosis of birds, but we will return to that later. Before the discovery of the bacillus of Koch, certain authors, in the name of pathological anatomy, disputed the tuberculous nature of 'pommelière.' However, since that time it has been proved experimentally that phthisis of man and 'pommelière' are of the same nature. M. Chauveau had shown that the two diseases, in all their forms, are equally inoculable in young cattle, and that the lesions consequent on ingestion or intravenous injection are always identical, whatever the origin of the inoculated product. The same assertions have been made by all those who have inoculated, for comparison, human and animal tuberculoses respectively into animals other than cattle; in the guinea-pig, notably, the lesions consequent on inoculation are always similar, whatever the source of the tuberculous material inoculated, and are exactly those which Villemin has so well described in his memorable book as characteristic of the inoculation of human tuberculosis.

In support of these experiments, the following are the details of an outbreak picked up by M. Cozette, veterinary surgeon at Noyon.* In a farm at Beauce, the stable, which was admirably kept, and quoted in the district as a model, contained twenty-four cows and one bull, all in very good condition. Tuberculosis had never been known in the stable, when, in 1886, two cows began to cough. It was decided to get rid of them, and they were put to fatten; they remained in bad condition, however, and were delivered over to the butcher, such as they were; they were tuberculous to such an extent that one of them had to be condemned. Soon one of their neighbours began to cough, then a second, and a third, and so on;

* *Bulletin de Société Centrale Vétérinaire*, 1894, p. 451.

in short, all the cows of the same row were attacked one after the other. They were sent to the slaughter-house as soon as they became ill, but, nevertheless, the disease persisted, so much so that in August, 1892, tuberculin showed that, of the twenty animals composing the herd, seven were tuberculous. All these seven animals belonged to the same row, the twelve in the other row being quite sound; and the autopsy of the seven animals confirmed the diagnosis.

How had the stable been contaminated? After a very careful inquiry, it was ascertained that, in 1883, three years before the recognition of the first cases, the farmer had engaged, as cowherd, a painstaking man, who was, however, in bad health, and had already been in hospital several times for pulmonary symptoms of a tuberculous origin. This man, who used to cough and expectorate constantly, and had occasionally had hæmoptysis, used to sleep in the stable immediately above the two cows, which were first recognised to be ill in February, 1886. The stay of the cowherd at the farm lasted till 1891, but was several times interrupted by his going into the hospital to be treated successively for 'inflammation of the lungs,' 'capillary bronchitis,' 'hæmoptysis,' and finally for 'pulmonary phthisis.'

There seems no doubt that these two cows in question were contaminated by matters expectorated or vomited during the night by this consumptive cowherd.

If the tuberculous man is dangerous for healthy cows, the converse is equally possible—at any rate, theoretically. One of my old pupils, M. Bigoteau, of Auneau, has noticed some interesting facts bearing on this point. Thirty-one of his clients had stables which had been infected for several years, and nineteen of them saw tuberculosis attack successively one or several (up to as

many as four) members of their families. When we consider that in the villages of Beauce, it is the custom to pass the winter evenings in the stable to economize fuel, we feel inclined to ask if these people did not contract the germ of the disease in the stable.

I do not know if there are in existence any well-authenticated instances of voluntary inoculation of the tuberculosis of animals into man; but there are authentic instances of accidental inoculation on record.

Tscherning of Copenhagen* had under treatment a veterinary surgeon who had wounded himself in the finger whilst making a post-mortem on a tuberculous cow. Three weeks after the accident, the small wound being already healed, the neighbourhood of the wound became swollen, and a little later the swelling became excoriated and suppurated. As the state of the part was becoming worse, Tscherning was obliged to interfere surgically, and he cut out the whole of the swollen part, in which the microscope showed tubercular nodules and bacilli. The inoculation had no other results, and this veterinary surgeon is at present a professor at the Copenhagen school.

A veterinary surgeon of Weimar, by name Moses, was less fortunate. In making a post-mortem on a tuberculous cow in 1885, this unfortunate colleague, thirty-four years old, of a good constitution, and free from hereditary taint, wounded himself deeply in the thumb of the left hand. The wound healed well, but six months later Dr. Pfeiffer, who reports the case,† diagnosed a cutaneous tuberculosis at the site of the scar. After the autumn of 1886 the patient showed unmis-

* *Compte-rendu du Congrès pour l'Étude de la Tuberculose*, Paris, 1888.

† *Zeitschrift f. Hyg.*, Bd. III.

takable signs of pulmonary tuberculosis, his sputum contained bacilli, and he died two years and a half after the wound. At the post-mortem, tuberculous arthritis of the inoculated thumb and pulmonary cavities were found.

Again, here are several instances of infection of man through the alimentary use of uncooked milk from tuberculous cows. I borrow the following example from Lydtin: Dr. Stang, of Amorbach, was asked to treat a boy, five years old, well developed, and born of healthy parents, whose families on both the father's and the mother's side were free from hereditary taint. The child died some weeks later from miliary tuberculosis of the lungs, with enormous hypertrophy of the mesenteric glands. While the post-mortem was being made it was ascertained that, a short time previously, the parents had had a cow slaughtered, which was found by the veterinary surgeon of the abattoir to be the subject of phthisis pommelière. This cow had been a good milker, and for a long time the boy had been in the habit of drinking its milk directly after it was milked.*

Four similar cases have been published by Dr. Demme, physician-in-chief to the children's hospital at Berne (Hôpital Jenner). These four children, the offspring of healthy parents, and without tuberculous ancestors either on the maternal or paternal side, died of intestinal and mesenteric tuberculosis, after having used, for a variable time, raw milk from tuberculous cows. Out of 2,000 tuberculous children treated by Demme in twenty years, these are the only cases in which he has been able to eliminate with certainty every other cause of the disease.†

* *Compte-rendu du 4me Congrès intern. vét. de Bruxelles*, 1883, p. 188.

† Demme: *Compte-rendu du fonctionnement de son service pendant l'année* 1882. Berne, 1883.

Here is another case, which is almost as convincing as an experiment: Dr. Gosse of Geneva, whose father and grandfather were doctors, had the misfortune to lose, last year, a grown-up daughter, seventeen years old. Up to the end of 1892 she was in perfect health, and had never exhibited the slightest sign suggestive of tuberculosis. But during the early months of 1893 she began to waste away, and for ten months all the doctors in Geneva examined her, and were unable to discover the cause of the wasting. Finally she died. Dr. Gosse had the courage to make a post-mortem examination, and found tuberculosis of the intestine and mesentery.

How had the girl contracted the disease? Heredity could not be alleged as the cause, seeing that none of her ancestors, either on the paternal or maternal side, had suffered from tuberculosis. The localization of the disease permitted one to assert its alimentary origin. It turned out that every week Dr. Gosse's family used to spend Sunday on the hills, at a small estate which he had inherited, and that one of the great delights of this young girl was to drink milk fresh from the cow. Perhaps the cows were tuberculous! The event proved the justness of the supposition, for, on being submitted to the test of tuberculin, four out of the five cows on the estate were found to be tuberculous: they were immediately slaughtered, and the autopsy showed that two of them had tubercular disease of the udder.

Dr. Gosse did not hesitate to bring these facts to the knowledge of his fellow-citizens, and, armed with them, he addressed a letter to the *Journal de Genève* (October 31, 1893), demanding, in the name of the public health, a strict inspection of all cows the milk of which was intended for consumption in its natural state.

If, then, the tuberculosis of man is transmissible to

the domestic animals—the mammalia, at any rate—the converse is equally true; that is to say, the tuberculosis of animals is transmissible to man.

A last argument of great value is supplied by the appearance of cultures of the tubercle bacillus, which is always the same, whatever be the origin of the seed (man, cow, horse, or pig); and by the identical action of the tuberculin extracts of the different cultures.

There is, therefore, no doubt as to the identity of the disease in the different species of the mammalia.

Virulent Products.—Use of the Meat and Milk.—For a long time it was believed that tuberculosis was a virulent malady in the old acceptation of the term, a general affection of the whole organism, so that each tissue and secretion contained in itself the germ of the disease. This idea gained renewed strength from the experiments of Toussaint (1880), who found that the most dissimilar products from a tuberculous cow (such as blood, nasal discharge, bile, urine, tears, muscle juice, vaccine, excrement) caused tuberculosis in animals experimentally inoculated.

Toussaint must have been the victim of experimental error, one of those accidental contaminations which are so common in dealing with tuberculosis; for all the experiments which have been made since—and their number is legion—prove that, in the immense majority of cases, the virulence resides only in the tuberculous lesions. But it is clear that, although the tuberculous material itself is alone virulent, yet any product with which it is mixed, in however small a proportion, may become virulent in its turn. The softening of a nodule, and its ulceration into a bronchus, with the consequent pouring of the caseous matter into the bronchus, explain the constant virulence of the expectoration. A similar process may

take place in any position, and when a nodule has ulcerated into a cavity, the contents of this cavity become virulent. In this manner urine, excrement, utero-vaginal mucus, milk, etc., may contain the bacillus of Koch.

Thus, the tubercular nodule may ulcerate through the wall of a bronchus, of the intestine, of the bladder, or of any excretory duct whatever. Similarly, the nodule may ulcerate through the wall of a bloodvessel, pour its virulent contents into the general circulation, and thus give rise to a general disease in the true sense of the word. At the exact moment when this occurs, the blood and all the vascular tissues may be virulent, and, if they were inoculated, might doubtless transmit the disease; but this general virulence is essentially a temporary affair; and the only bacilli which remain alive and multiply are those which the chances of the circulation have stranded in organs favourable to their growth (lungs, liver, spleen, glands, medulla of bones, mammæ, etc.,); those which have been arrested in the muscles are very quickly destroyed.

At the first congress on tuberculosis in 1888, I recounted experiments which proved that in a few hours the blood got entirely rid of all the tubercle bacilli introduced into it by intravenous injection, in however large numbers; and that in a few days the innumerable bacilli which are arrested in the muscles as a result of this experiment are, if not destroyed and digested, at any rate rendered innocuous, and have lost at the same time their capability of growing and their virulence.

With reference to the *virulence of the blood*, Bang recounted to the Congress of Hygiene at London in 1891 some experiments of the greatest interest.

'I inoculated,' said he, 'the defibrinated blood of

twenty highly-tuberculous cows into thirty-eight rabbits and two guinea-pigs. The method of inoculation employed was injection into the peritoneal cavity, and the dose varied from 10 to 18 cubic centimetres. The result was negative in eighteen cases and positive in two cases. In these two cases, only one of two rabbits inoculated showed tuberculous lesions: in the one case the lesions were very insignificant; and in the other, the cow from which the blood had been taken was affected by an acute miliary tuberculosis following the injection of tuberculin, and three weeks before I had injected the blood of this same cow, and it had then proved harmless. It is, moreover, right to add that among the eighteen negative cases there were several of acute miliary tuberculosis.' For my own part, I have never succeeded in causing tuberculosis by the intraperitoneal injection of blood collected pure from tuberculous cattle.

Are the *muscles* of the tuberculous animal virulent? Certainly it would seem that, as the experiments of Chauveau have shown the danger of the ingestion of tuberculous material, and as the custom of eating meat grilled, that is to say, insufficiently cooked in its central parts, is becoming common, the meat of the tuberculous animal ought to be forbidden as food.

For the last ten years this question has been discussed in all the congresses of hygiene or veterinary medicine. It has been the object of a considerable number of researches, and it has such an importance from the double point of view of public health and inspection of butcher meat, that I think I ought to treat it in some detail.

My illustrious master, H. Bouley, entirely adopted the ideas of Toussaint: in his opinion tuberculosis was a virulent general disease, and every tuberculous animal

was a public danger, and its consumption as food ought to be forbidden. In his writings and in his lectures at the Muséum, he made a vigorous campaign in favour of what was known as 'the total seizure'—that is to say, the seizure and destruction of the entire animal, whatever the degree of the malady, however minute the lesions.

At the International Veterinary Congress, held at Brussels in 1883, he succeeded in making this radical proposal win the day against the much more moderate one supported by M. Lydtin of Karlsrühe; but it is only right to say that, there being no time for the discussion of M. Lydtin's remarkable paper, many of those present abstained from voting, and that the proposal was only passed by a majority of one. No country, moreover, has put into practice this hasty decision of the Congress of Brussels, and M. Bouley himself has since that time recognised that it was too extreme. It is especially since 1883 that numbers of experiments have been made, which establish the fact that the results obtained by Toussaint are far from being constant, and that in the immense majority of cases the virulence remains confined to the tuberculous lesions, the blood and muscle juice only being virulent in very exceptional cases.

This is the explanation of the resolution voted in October, 1885, by the National Congress of French Veterinary Health Officers: 'The consumption of the meat of tuberculous animals, even when it has a good appearance, ought to be forbidden in all cases where tuberculous lesions of a viscus or a serous membrane show a tendency to become generalized—that is to say, have passed the barrier of the lymphatic glands connected with these organs.' This prudent resolution abolishes the shadow of a danger, and ought to reassure the most

timorous. It was, however, thought insufficient by the great majority of the members of the International Veterinary Congress of 1889, and of the congresses for the study of tuberculosis held in Paris in 1888 and 1891. Carried away by the vehement pleading of M. Arloing, these three important assemblies affirmed 'the necessity for the total seizure, however good the apparent quality of the meat, and however limited the tuberculous lesions might be.' In vain I have protested against the excessive and unjustifiable severity of this measure: I have never been able to rally more than a very few votes. On the other hand, at the International Congress of Hygiene held in London in August, 1891, it was the idea of 'the restricted seizure' which was defended by the very large majority of the experimenters.

Let us glance rapidly over the experiments invoked in the cause of 'total seizure.' These experiments have consisted mostly in expressing the juice of a certain quantity of chopped meat, generally taken from an animal affected with generalized tuberculosis, and injecting it into the peritoneal cavity of a certain number of guinea-pigs in doses varying from $\frac{1}{2}$ a cubic centimetre to 5 or 10 cubic centimetres and more.

Experimenting in this way, it has been found, firstly, that, out of ten tuberculous cattle used in the experiment, there is never more than a very small number (one, two, or sometimes none) of which the muscle juice proves virulent; and, secondly, that, out of ten guinea-pigs inoculated with the muscle juice of the dangerous subject, never more than a small number (one, two, or three) become tuberculous.

To those who know with what ease, rapidity, and certainty the guinea-pig contracts tuberculosis by intra-peritoneal inoculation, it is evident that the seven, eight,

or nine guinea-pigs which escaped infection received muscle juice which either contained no bacilli or else a very small number.

It is justifiable, then, to draw the following conclusion: The meat of cattle suffering from tuberculosis, even when the disease is generalized, only rarely contains tubercle bacilli, and when it does, only contains a very small number of them.

We are not justified in concluding that, if this meat had been used as food, it would have been able to tuberculize the persons who consumed it, because it tuberculized certain of the guinea-pigs which received it in the peritoneal cavity. This would be tantamount to saying that ingestion is as certain and reliable a method of transmitting the disease as intraperitoneal injection, which, as we have already seen, is far from being the case.

The experiments of Gerlach and Jöhne, who frequently gave tuberculosis by the digestive tract, are often referred to; but it must be remembered that these experiments were made long ago, at a time when the virulence of tuberculous matter itself was disputed; that these experimenters used viscera and affected glands, as well as muscle; that to a dead certainty Jöhne did not dream, any more than Gerlach, of making sure that the meat given to the experimental animals did not contain some tuberculous gland, or had not been contaminated by some virulent material (nasal discharge, pus, bronchial mucus, etc.). The more recent experiments of Veysièrre and Peuch do not seem to have been done with any more precautions for the avoidance of accidental contaminations. Peuch makes the assertion that the meat was boned, and the mention of only this precaution seems to indicate clearly that the other precautions necessary for

the decisiveness of the experiments had been neglected. Therefore the experiments in question return to the catalogue of those where tuberculosis has been set up by the ingestion of tuberculous products rich in bacilli, experiments which nobody disputes, but to which nobody would appeal in support of 'total seizure.'

In comparison with these experiments, the arrangement of which leaves much to be desired, here are some others which demonstrate clearly that a product which is fatal when injected into the peritoneal cavity, may be ingested with impunity, even in considerable quantity.

Viseur showed how sensitive kittens are to the ingestion of tuberculous material.

I have fed several litters of kittens on the meat of cattle condemned at the abattoirs of Villette or Grenelle for general tuberculosis. None of them ever became tuberculous. On the other hand, all the kittens which I made eat a small portion of tuberculous lung, liver, or gland, succumbed to abdominal tuberculosis after a period varying from six weeks to five months. Of all these experiments I wil only relate the following, because among the cows whose meat was consumed figures the only cow the muscle juice of which I have seen cause tuberculosis, and that in one only of four guinea-pigs inoculated, the method of inoculation employed being that of intraperitoneal injection.

'Four cats, born March 4th, 1888, ate on four occasions, namely, April 10th and 15th and May 3rd and 8th, each of them, a total quantity of 2 kilogrammes of raw chopped meat taken from the crural muscles of cows condemned for general tuberculosis. None of the animals became tuberculous.'

Thus, these animals were able to eat with impunity 500 grammes apiece of a meat which certainly contained

bacilli, since the juice of this meat injected into the peritoneal cavity of four guinea-pigs killed one of them. Peuch himself communicated to the first congress on tuberculosis an experiment which shows well the enormous difference existing between the effects of ingestion and those of injection into the peritoneal cavity.

'A pig, two months old and weighing 14 kilogrammes, drank, in five days, 4½ litres of milk from a tuberculous cow which was so ill that its death interrupted the experiment. Four rabbits received into their peritoneal cavities 10, 20, 30, and 40 cubic centimetres respectively of the same milk. The four rabbits became tuberculous, but the pig, when killed fifty-six days after the experiment, was absolutely healthy. The pig had drunk 4½ litres of milk which came from a tuberculous udder, and certainly contained bacilli.'

Galtier presented to the second congress on tuberculosis the result of experiments which consisted in feeding dogs, cats, poultry and guinea-pigs almost exclusively on raw meat from tuberculous animals. None of these animals contracted the disease.

More recently Galtier has repeated these experiments, using on this occasion animals which become easily and frequently tuberculous under natural conditions.*

'A calf, six weeks old, consumed in a month 4 kilogrammes of raw meat from cows condemned for general tuberculosis; another calf, four or five months old, had three large meals of tuberculous meat. At the autopsy neither of these cows showed the least trace of tuberculosis.

'Two pigs, five to six months old, were able to eat with impunity considerable quantities of condemned meat—2 kilogrammes on February 26th and 27th, 3 kilo-

* *Journal de l'Ecole de Lyon*, Août, 1892.

grammes on March 14th and 15th, 3 kilogrammes on March 24th and 25th, and 2 kilogrammes on March 27th and 28th.'

Thus these four animals, whose great receptivity is undoubted, both as to age and species, were able to eat repeatedly large quantities of tuberculous meat without any of them taking the disease. This result is all the more impressive from the fact that two out of the fourteen samples of meat used for the experiments caused tuberculosis in rabbits when the juice was inoculated.

In a new series of experiments, which gave similar results, two pigs, four months old, each ate on separate occasions 3 kilogrammes, $2\frac{1}{2}$ kilogrammes, and 6 kilogrammes respectively of raw meat from tuberculous cows which had been condemned at the abattoir. At the autopsy the two subjects of the experiment showed no tuberculous lesion.*

Perroncito has published some analogous experiments just as convincing: Eighteen young pigs were fed for three, four and five months on meat from tuberculous cattle condemned at the abattoir at Turin; at the autopsy none of these animals were found to be tuberculous.

Lastly, Bang has shown that a tuberculous milk, kept for five minutes at a temperature of 70° C. (and sometimes even below that), still kills animals when intraperitoneally inoculated, whilst animals of the same species may drink large quantities of the same milk without ever becoming tuberculous.

It must not be forgotten that all these last experiments have been made with meat from animals attacked by generalized tuberculosis, meat the seizure and destruction of which everyone demands; and yet in these

* *Bulletin de la Société Centrale Vétérinaire*, 1893, p. 186.

animals, in which lesions, everywhere softened, ulcerated and bursting, have invaded all the organs, experiment proves that the muscular tissue only rarely contains bacilli, and that, if it does so, it is in such small quantities that it may be ingested with impunity, even quite raw, by the animals which are most sensitive to tuberculosis. If this is the case in generalized tuberculosis, *a fortiori* will it be the case in tuberculosis not generalized, and it is only in this latter case that the advocates of the 'restricted seizure' demand that the consumption of the meat should be allowed.

Besides, light is being thrown little by little on this question, and at the present time everywhere in Europe, except in France, the meat of tuberculous animals—if that meat appears to be good in quality—is not condemned, unless the tuberculosis has become generalized in the true sense of the word.

In Germany, notably, a new order, dated March 26, 1892, has just mitigated still more the not very rigorous treatment hitherto adopted in that country with regard to tuberculous meat. This important document is signed by the Minister of the Interior, the Minister of Agriculture, the Minister of Public Instruction and Hygiene, and the Minister of Commerce and Industries. These are the new regulations which it prescribes:

'The meat of tuberculous animals is to be declared *unwholesome* when there exist tubercular nodules in the muscles, and also when, without the existence of nodules in the muscles, the meat comes from a wasted animal.

'On the other hand, the meat of tuberculous animals is be declared *not unwholesome* if, the animal being in good condition, the tubercular nodules exist in one organ alone, or in two or more organs which are in connection with one another, either directly or by means of blood-vessels *which do not belong to the general circulation.*

'In fact, the very numerous experiments made at Berlin and in a

great number of German universities prove that, with the exception of the very rare cases in which tubercular nodules are found in the muscles, the ingestion of meat from tuberculous animals is powerless to transmit tuberculosis.'

This is the opinion which I have always and everywhere defended, moreover without any success—in France, at any rate.

The *milk* of tuberculous cows is sometimes virulent. As it retains even then all the appearances of milk of good quality, and as the bad habit of drinking milk raw is almost universal—there being an absurd and widespread idea that boiled milk is indigestible—it is easy to understand the serious dangers presented by the alimentary use of tuberculous milk, especially in the case of children or invalids, who use it as their sole and principal food.

Gerlach was the first to raise the alarm. He fed young animals (calves, pigs and rabbits) with milk from tuberculous cows, and found that some of them wasted rapidly and died at the end of a few months, the autopsy showing an intense tuberculization of the organs of the abdominal cavity.

All these animals did not die. Whilst in some batches, to which the milk of the same cow had been given, all the animals died ; in other batches, supplied with milk from another cow which was manifestly tuberculous, none of the animals became ill.

Klebs, Jöhne, Böllinger, and Peuch got the same results, but Harms and Günther did not succeed in making tuberculous any of the animals on which they experimented.

These contradictory results are easily explained if one admits, with Böllinger, that the milk of a tuberculous cow is only virulent when the udder is infiltrated by

tubercular nodules. The circumstance is then in accordance with the general law formulated earlier in this chapter, viz.: 'When tuberculous lesions invade the wall of an excretory duct, sooner or later ulceration takes place, and from that time onward the secreted liquid acquires tubercular virulence by reason of its admixture with the softened contents of the nodules.'

In my experience I have never found the milk virulent when the udder was free from tuberculous lesions; and tuberculosis of the udder is comparatively rare, for out of fifty-four cows which had been seized for general tuberculosis, which I studied especially with this object in view, only three had tuberculosis of the udder.

At Copenhagen the proportion is still lower, and Bang estimates it at less than 3 per. cent. of the number of tuberculous cows.

But some authors have put forward the view that the milk may be virulent even when the udder is free from tuberculous lesions.

Hirschberger *inoculated into the peritoneal cavity* of rabbits and guinea-pigs the milk of twenty-nine tuberculous cows, whose udders appeared healthy, and caused infection to the inoculated animals fourteen times.

Bang, operating in the same way with twenty-eight cows, seized for general tuberculosis, but whose udders were clinically healthy, obtained only two positive results. On the other hand, the milk of eight tuberculous women tested in the same fashion never showed itself virulent. In a second batch of experiments, Bang tested the milk of twenty-one equally tuberculous cows, and found the milk virulent four times. In a third batch, out of fourteen subjects used for the experiments, three had tuberculous milk. To sum up, out of sixty-three cows

nine gave milk containing bacilli; but, as Bang with justice observes (International Congress of Hygiene at London), nearly all the cows were tuberculous in a very high degree—some died of acute miliary tuberculosis, and three of the four positive cases in the second batch showed at the autopsy tuberculous lesions of the udder, which were too little developed to be diagnosable in the living subject. In one case the udder appeared absolutely healthy, and yet the supra-mammary lymphatic glands were infiltrated by tubercular nodules.

All these considerations tend to establish the fact that, in cases where the suspected udder has appeared not to be tuberculous, it is because the lesion has not been carefully enough looked for. Not to mention the case of tuberculous follicles still in an embryonic state and invisible to the naked eye, one can easily imagine the difficulty of finding miliary nodules in the midst of the lobules of the mammary gland, especially at a time when the nodules have not undergone calcareous infiltration.

Again, we must note that in all these experiments the method of inoculation employed was intraperitoneal injection, and that the number of bacilli contained in the milk must have been very small, since, in three of the positive cases obtained by Bang, only one of several guinea-pigs inoculated became tuberculous.

It is, then, pretty certain that if the milk had been ingested, instead of being injected into the peritoneal cavity, it would have remained harmless.

The experiments of Peuch, already mentioned, show well the importance of the *quantity* of the bacilli in affecting the results of ingestion of tuberculous milk. A young pig was able to drink with impunity in five days $4\frac{1}{2}$ litres of milk secreted by a tuberculous udder, when a

very small dose of the same milk injected into the peritoneal cavity killed the rabbits in a few weeks.

Again, we have seen that such and such a milk kills all the animals fed on it exclusively, but that when one comes to dilute it with fifty times its volume of sound milk, the same animals can drink it *ad libitum*, without any of them becoming tuberculous (Gebhardt).

From all these facts, we may draw the following conclusions :

(1) That the milk of a tuberculous cow is only virulent when the udder is the seat of tuberculous lesions.

(2) That the ingestion of a virulent milk is only dangerous when the milk contains a great number of bacilli and is ingested in considerable quantity.

(3) That practically the danger from the ingestion of raw milk only exists for persons who use it as their sole or principal food ; that is to say, for young children and certain invalids.

(4) That, to avoid all danger, it is sufficient to bring the milk to the boil before it is consumed.

It has been alleged that the boiling of milk renders it indigestible, and causes it to lose much of its nutritive value. This is absolutely untrue. All doctors who have made a study of the question are now agreed that children digest boiled milk just as well, if not better, than raw milk.

Moreover, the substitution of boiled milk for raw has not only the advantage of abolishing all danger from tuberculosis, but it also has a marked effect in diminishing the number of deaths and illnesses due to intestinal affections which are so common during the hot weather.

But, it may be said, although boiling is sufficient to protect us against dangers from the milk, it is inapplicable to the products derived from the milk ! And the

experiments of Bang, Galtier, Heim, and Gasperini have shown that both butter and cheese may keep alive for a long time the tubercle bacilli which were contained in the tuberculous milk used in their manufacture.

The experiments of Bang have shown that most of the bacilli are carried off in the butter-milk and whey, though a certain number will always remain in the butter and cheese. It was for this reason that Bang made researches to find out the lowest temperature at which the milk could be heated in order to kill the tubercle bacilli before the manufacture of the butter and cheese. The temperature of 85° C. prolonged for five minutes kills all the bacilli; the temperature of 80° C. sometimes kills them; the temperature of 70° C. prolonged for five minutes does not kill the bacilli, but it affects their vitality so profoundly that, though they are still capable of transmitting tuberculosis to animals by intraperitoneal inoculation, they are no longer capable of transmitting tuberculosis to animals which ingest large quantities of the milk so heated.

A similar result is obtained in the majority of cases when the milk is heated at about 65° C. for fifteen or twenty minutes.

This Pasteurization of the milk and cream is at present in general use in Denmark. It has the additional advantage of delaying for more than twenty-four hours the commencement of the ordinary fermentations, and in this manner greatly facilitates the industrial utilization of these products. From our point of view, this practice has the great advantage of reducing to a minimum the danger from the alimentary use of milk and its derivatives.

But even in the absence of all heating, we believe that butter and cheese, even from an unknown source, may be eaten without fear. We know that *ingestion* is not

dangerous, unless the material is very rich in bacilli, and is ingested in large quantities. Then, we have just seen that the butter-milk and whey retain most of the bacilli contained in tuberculous milk, and we know that butter and cheese form only a very small portion of the food of man. Thus, the danger from butter and cheese, which is a possible one theoretically, is practically reduced to nil.

Is the *vaccine* taken from a tuberculous subject virulent? Toussaint said it was, on the strength of his experiments, but all those who have since repeated his experiments obtained quite opposite results. Lothar-Meyer, Straus, and Josserand have studied the vaccine obtained from tuberculous men; but histological examination never discovered in it the specific bacillus, and the inoculation of it into the guinea-pig remained without effect. I have repeatedly collected large quantities of vaccine lymph from cows suffering from very advanced tuberculosis, and inoculated it into numerous guinea-pigs, some of them receiving as much as 1 and 2 cubic centimetres into the peritoneal cavity, but none of them ever became tuberculous.

If I insist on this point, it is because the natural sequel to the experiments of Toussaint would be the abandoning of animal vaccination (one of the greatest triumphs of modern prophylactic hygiene).

First of all, we know how rare tuberculosis is in the calf; and, secondly, we know that the inoculation into the skin with a lancet of even a very virulent product does not succeed in producing tuberculosis. Supposing, then, that the vaccine might be virulent—which it is not—the danger of the transmission of tuberculosis by vaccination would be nil.

Nevertheless, so as to be free from all criticism, it is necessary not only to select the calf which is to act as a

vaccinifer, but also to make no use of its lymph till after the animal has been slaughtered, and it has been ascertained that it was not suffering from any tuberculous lesion, or any disease whatever. The general public is in this way protected from all danger, even imaginary. This is, moreover, the method of procedure adopted by most of the establishments which cultivate, store, and send out animal vaccine.

More simple still and more certain is the procedure of Professor Leclainche of Toulouse. Being intrusted with the production of the vaccine used by the whole district, he does not inoculate his calves till after they have been submitted to the test of tuberculin.

Sanitary Police and Prophylaxis. — The decree of July 28, 1888, added bovine tuberculosis to the list of contagious diseases scheduled in the law of July 21, 1881. The general clauses of this law—notification, isolation, prohibition of sale, etc.—are therefore applicable to animals affected, or suspected of being affected, by tuberculosis, and offenders are liable to penalties enacted by Article 30 and the following articles. But in addition to this, a Ministerial decree of July 28, 1888, points out, in Articles 9 to 13, the sanitary measures specially suitable in the case of tuberculosis :

'Article 9.—When tuberculosis is discovered in any animal of the bovine species, the Prefect is to issue an order to put the animal under the surveillance of the veterinary health officer.

'Article 10.—Every animal recognised to be tuberculous is to be removed from its neighbours and isolated. It must not be sent away, except in order to be slaughtered.

'The slaughtering is to take place under the sur-

veillance of the veterinary health officer, who is to make the autopsy, and send to the Prefect the written notes of the autopsy within five days of the slaughtering.

'Article 11.—Meat from tuberculous animals is to be excluded from consumption—

'(1) If the lesions are generalized, that is to say, are not confined to the visceral organs and their lymphatic glands.

'(2) If the lesions, although localized, have invaded the greater part of a viscus, or show themselves by an eruption on the walls of the chest, or of the abdominal cavity.

'This meat, forbidden as food, and also the tuberculous viscera, are not allowed to be used for the feeding of animals, but must be destroyed.

'Article 12.—The use of the skins is not permitted till after disinfection.

'The sale and use of the milk coming from tuberculous cows are forbidden. However, the milk can be used on the spot for the feeding of animals, after it has been boiled.'

It will be noticed that the prescribed measures apply only to the animals in whom tuberculosis is diagnosed; no measure is prescribed for the neighbouring animals to the one affected, namely, those animals which, as the result of a prolonged and intimate cohabitation, might reasonably be suspected of being contaminated. The legal sanitary measures are, then, obviously inadequate from a prophylactic point of view. The disease may, therefore, freely continue its ravages in the stable; and, what is more serious, the owner is at perfect liberty to sell the contaminated neighbours of the tuberculous animal, each of which may infect the new stable into which it is introduced.

This simple criticism shows the necessity for a revision of the provisions of the decree of July 28, 1888.

Again, take Article 10, which enacts that the tuberculous animal be isolated, and not removed except for slaughter. This rigorous measure was quite justifiable at a time when the veterinary surgeon had to rely on clinical examination alone to ascertain the existence of tuberculosis; since, by the time he could give a decided opinion on the subject, the disease had already reached an advanced stage of its evolution, and from that time forward the animal was to be considered highly dangerous from an infectious point of view. It was not to be moved, for fear it sowed the seeds of the disease everywhere on its journey. But now that tuberculin permits one to ascertain the existence of any tuberculous lesion, however small, it would be excessive, it would be absurd, to apply Article 10 to the letter.

On the other hand, it is clear that, if rigorous isolation is to cease, the provisions destined to prevent the sale of animals recognised to be tuberculous must be made more stringent. But we need not wait for the amendment of the decree of July 28, 1888, to begin the struggle against tuberculosis. All those engaged in agriculture, in breeding, rearing, feeding, or fattening, ought to carry out, each for himself, the prophylaxis of the disease. Each of them is directly interested in it. The methodical use of tuberculin, by denouncing the sick animals at the outset of the disease, permits one to isolate them, and to protect the sound animals from all danger of contamination.

As the young animals mostly escape the infection, breeding would not be seriously interfered with, and the vacant spaces would be filled in a few years.

Of course, a farm, once made healthy, ought to be protected from reinfection; to effect this, it would be

sufficient to introduce into it no new animals without having them previously tested with tuberculin.

Thanks to these simple means, owners of cattle by their own action would be able, quickly and with little expense, to free themselves from the heavy tribute which they pay every year to tuberculosis, and that, too, without any assistance from the State.

Treatment. — Bovine tuberculosis has been hitherto looked upon as an incurable disease; at any rate, the numerous treatments which have been from time to time extolled have always been found powerless when put to the test. Perhaps this was because the treatment was tried at too late a stage of the disease. Formerly, by the time one could assert that a cow was suffering from tuberculosis, the disease was already so far advanced that it was easy to understand the uselessness of attempting any treatment. But to-day, when tuberculin permits us to ascertain the existence of the most recent and most limited tuberculous lesions, the possibility of an efficacious treatment must be admitted. Seeing that it is in cattle that we most often observe the fibrous or calcareous transformation of tuberculous nodules, which the doctors of man consider the natural method of healing of a lesion, may we not hope something from injections of creasote, which give such good results in the hands of some doctors?

I have been able during the last two years, with the assiduous co-operation of M. Gellez, veterinary surgeon at Carvin, to make a certain number of experiments, of which the results are very encouraging.

In October, 1892, we had occasion to test with tuberculin all the cattle on a fine large farm in the North of France. A considerable number of them were found to be tuberculous, and most of these were sent to be

slaughtered; but fifteen of them, prize-bred beasts, were kept for the purpose of being treated with creasote. Twice a week, for a period of from six to eighteen months, each of these animals received a subcutaneous injection of creasote and oil. The dose varied, according to the age and size of the sick animal, from 10 to 25 grammes of pure creasote, mixed with an equal amount of sterilized oil. In July, 1894, nine of these fifteen animals could be looked upon as definitely cured, as on two successive trials the tuberculin had set up no reaction in them; and still further, one of the nine was slaughtered, because it was unfit for breeding purposes, having been covered several times without result, and I was enabled to make the post-mortem examination of it. The two lobes of the lung contained a score of tuberculous nodules, which were either fibrous or calcified. Three of the mediastinal glands contained nearly as many in the same state. I inoculated these nodules, after reducing them to a pulp and diluting them with boiled water, into six guinea-pigs, both under the skin and into the peritoneal cavity. None of the inoculated animals became tuberculous: the nodules were no longer virulent: the cow had been healed of its tuberculosis.

Was the healing of these nine animals to be attributed to the creasote? I would not venture to say that it was.

As a matter of fact, among the other cows found to be tuberculous at the first trial with the tuberculin, and kept apart till their calving was over, but not treated in any way, two were found to be healthy six months afterwards, when they were tested a second time with tuberculin. These latter two animals, removed from infected surroundings, grazing at liberty, protected from every opportunity of new contamination, had undergone a natural cure. Perhaps it had been the same with regard

to the animals treated by creasote. In any case it is highly probable that the creasote greatly helped in the cure of these sick animals.

By permitting the recognition of tuberculosis at the outset, at a time when there exist only very limited lesions, inaccessible to all other methods of diagnosis, tuberculin opens a new door for attempts at the treatment of the disease.

In the last few years, the injections of the serum of the goat or dog have been recommended in the treatment of human tuberculosis. It was thought that these animals were refractory to tuberculosis. We know now that this is not the case, and experience has not confirmed the hopes entertained for this form of treatment. More recently Richet and Héricourt have tried to vaccinate dogs against human tuberculosis by submitting them to repeated intravenous injections of large quantities of tuberculosis avium. Many of the dogs which are used for the experiments succumb to the injections; some are able to stand the injections, and acquire in the long-run a substantial immunity, and the serum of these latter possesses, according to these authors, a most remarkable preventive and curative action with respect to tuberculosis.

According to Dr. Vicquerat of Moudon (Switzerland), the same results may be obtained much more surely by using the ass instead of the dog. These researches, however, are still in the experimental stage, and up to now there is nothing to justify one in recommending the application of this treatment to the tuberculosis of man or animals.

CHAPTER II.

TUBERCULOSIS OF THE PIG.

TUBERCULOSIS of the pig is much less common than that of the cow, but it is not so rare as that of the calf.

In Saxony, there were slaughtered in the abattoirs under inspection : In 1891, 54,444 adult cattle, of which 9,476, or 17·4 per cent., were tuberculous ; 230,808 pigs, of which 2,477, or 1·07 per cent., were tuberculous ; 126,322 calves, of which 78, or ·06 per cent., were tuberculous. In 1892, 276,851 pigs, of which 3,804, or 1·37 per cent., were tuberculous. In 1893, 309,200 pigs, of which 5,100, or 1·64 per cent., were tuberculous (Jöhne).

At Amsterdam, in 1890, of 22,813 cattle slaughtered, 755, or 3·3 per cent., were tuberculous, while of 30,406 pigs slaughtered, 323, or a little more than 1 per cent., were tuberculous (Thomasset).

On the other hand, at Rouen, M. Veyssière only found 15 tuberculous pigs out of a total of 38,164 slaughtered, during four years, or less than ·04 per cent.

In the duchy of Baden, the percentage is still lower, for, out of a total of about 8,000 pigs slaughtered each year from 1874 to 1882, only 22, on an average, were found to be tuberculous, or a little less than ·02 per cent. (Lydtin).

Young animals belonging to precocious breeds seem to be more liable than others to tuberculosis.

In nine cases out of ten, the pig is infected by ingestion. The piggeries where the refuse from butter and cheese manufactories is consumed, and those which adjoin abattoirs or knackers' yards, supply the majority of the animals which are found at the abattoir to be tuberculous.

The mechanism of infection is simple. We have seen how easily the pig becomes tuberculous when it is fed on material rich in bacilli; and if one is imprudent enough to feed the pigs on the refuse from dairies and cheese manufactories, or on tuberculous viscera, these conditions are realized.

A tuberculous sow, too, may infect all its young, when its teats are infiltrated by tuberculous nodules.

Infection by the respiratory tract is certainly possible, but it is rare, owing to the fact that the affected animals are usually slaughtered before the softening of the pulmonary lesions has been able to give rise to a virulent expectoration.

Experiments show the possibility of infection by means of the sputum of man.

Lesions.—In the pig, tuberculosis manifests itself by miliary granulations, which rapidly become yellow and caseous, as in cattle, but which are much more rarely infiltrated by calcareous salts. Generalization is common, and all the viscera are then, as it were, stuffed with gray granulations, which are translucid throughout, or opaque in their centres, and are quite analogous to those which we have already described.

The malady most often results, as we have said, from the ingestion of virulent matters. It is, then, through the digestive apparatus that it breaks out, and the corre-

sponding *lympathic glands* (tonsils, and the following lymphatic glands :—submaxillary, parotid, pharyngeal, superior cervical, mesenteric, sublumbar, etc.) may be already markedly altered when the organs are as yet almost completely intact. Lesions of the *small intestine* and of the cæcum are common, and take the form of ulcers of the mucous membrane, of miliary nodules, or of tuberculous infiltrations involving at once the mucous, the muscular and subserous tissue. The *liver* is attacked in almost every case, and its lesions take the form either of miliary granulations, which are yellow and caseous and scattered in great numbers through the thickness of the organ, or else of rounded nodosities which are yellowish-white in colour, about as big as a pea or a hazel nut, and of a tough consistence ; these nodosities on section show themselves to be sometimes firm, homogeneous, sarcomatous, or fibrous in appearance ; sometimes softened in the centre ; sometimes, but rarely, infiltrated with calcareous salts. *The peritoneum* and *the pleura* are sometimes the seat of an eruption of fine granulations, which remain in the state of miliary nodules, and have no tendency to the budding so characteristic of pommelière. Lesions like those of the liver may exist in *the lung*, but generally there is found in the lung an innumerable quantity of minute translucid gray granulations, caused by generalization through the blood-stream ; in which case, the liver, the spleen, the kidneys, the medulla of the bones, and the mammæ, are infiltrated by identical growths.

It is common to find lesions localized in one or several lymphatic glands. The tonsils and the pharyngeal or submaxillary glands are the most often affected ; they become voluminous, hard, and knotty ; they have undergone a true fibrous transformation ; they are difficult to

cut, and their tissue creaks under the cutting instrument, and on section has quite the appearance of old fibrous tissue; here and there small yellow islets are seen of a softer consistence, almost caseous; sometimes even veritable purulent collections are found, either encysted or in communication with the exterior by a fistula. If one submits the caseous or purulent matter to bacteriological examination, one does not usually find the bacilli of Koch. The bacillus, however, is there, because this matter, when it is inoculated into the peritoneal cavity or the cellular tissue of a guinea-pig, sets up in it a bacillary tuberculosis.

These chronic glandular lesions, with their very slow progress, quite compatible with a satisfactory general state, have long been looked upon as constituting the *scrofula* of the pig; and to scrofula were also assigned the tuberculous lesions of bones (ribs, vertebræ, articular extremities, shoulder-blades, hip-bones, etc.) which are common in pigs, both young and old.

The old authors had already noticed that the ancient scrofula was often accompanied by visceral tuberculosis, but they refused to admit the identity, and even the relationship, of the two affections.

Symptoms.—In most cases tuberculosis of the pig develops without anything drawing the attention of the swineherd to the affected animal, and it is only recognised at the abattoir. Sometimes, however, it causes local and general troubles, which vary according to the organ or system attacked.

Its localization in the abdominal organs causes the arrest of fattening, and then the progressive wasting of the subject. The mucous membrane becomes pale; the hide becomes dirty; constipation, meteorism, colic, and passing diarrhœa are noticed. The animal is in low

spirits, and remains buried in its straw for entire days; the corkscrew of the tail is straightened; the belly is pendulous and the eye sunken; palpation of the belly is painful, and may reveal more or less voluminous masses, which are hard and mammillated, and result from the changes in the mesenteric glands. It is common to find some glandular tumour in the submaxillary region, at the level of the neck, or at the thoracic inlet. In this form the malady may last several months, but death supervenes rapidly if the lesion is generalized through the blood-stream. Primary pulmonary tuberculosis is very rare, but sooner or later lung lesions complicate abdominal tuberculosis, and betray themselves at the outset by a short, dry, abortive cough, and by difficulty in respiration. The cough soon becomes paroxysmal and painful, and is often succeeded by vomiting; the respiration becomes hurried and gradually painful and more difficult; wasting is very rapid, and death supervenes in a few weeks.

When the meninges and nervous centres of the brain or spinal cord are attacked, symptoms are observed corresponding to the localization of the lesion, and the co-existence, in any position whatever, of a specific glandular tumour permits one to attribute to their proper cause the symptoms which have been observed.

The scrofula (glandular tuberculosis) usually shows itself by a sort of puffing up of the face, with tumefaction of the parotids, which a careful examination shows to be lifted up by the subjacent glands, which are enlarged, indurated, still fairly mobile, and free from heat or tenderness. The retro-pharyngeal, superior cervical, and sublingual glands usually take part in the lesion, forming a kind of necklace of unequal and knobby tumours, which extend from ear to ear, and

become larger under the neck between the two rami of the lower jaw. Similar tumours may be developed at the thoracic inlet, behind the shoulder or in the groin, which, as they increase in size, become harder and more adherent to the neighbouring tissues; sometimes, however, slight fluctuation is perceptible at one point of their surface, the tumour softens, then forms an abscess, and discharges a small quantity of thick and grumous pus; but the glandular tumour does not disappear, and the opening into the abscess remains for long as a fistula.

At the same time one may notice swellings of the bones, causing a true tuberculous arthritis when the lesion happens to be situated at the level of an epiphysis. Persistent lameness, fistulous wounds suppurating indefinitely, necrosis, caries, etc., are the complications of these lesions of the bone, the evolution of which is always extremely slow.

Diagnosis.—It is but seldom that the veterinary surgeon is consulted on the subject of a living tuberculous pig. Most often it is after death that he is called to give his opinion on the nature of the lesions observed, in which case there is not usually any real difficulty. In case of doubt, however, he must not rely too much on the microscopical examination, for in the pig, much more than in the cow, the finding of the bacillus is difficult, and the negative result of the search does not justify the conclusion that tuberculosis is absent; to the examination of cover-glass smears prepared on the spot by scraping must be added the methodical study of sections, and, above all, inoculation. In the sections, even in the absence of bacilli, one may be certain of the nature of the lesion by the discovery of typical tuberculous follicles almost always rich in giant-cells.

Inoculation of the guinea-pig, made into the peritoneal

cavity, and into the subcutaneous cellular tissue of the internal surface of the thigh, enables one to acquire quickly enough the certainty which was lacking. Indeed, although the guinea-pig usually resists for a long time, especially when the inoculated product comes from a chronic lesion, either of bone or gland, the glands of the fold of the flank become rapidly enlarged, then indurated, and then obscurely fluctuating. These glands may be punctured or extirpated, and their contents examined for the bacillus; if the result is still negative, these contents may be inoculated into a second guinea-pig, which in eight or ten days, the same procedure being made use of, will give the required answer.

It is sometimes possible to take for tuberculous lesions the changes caused by infectious pneumo-enteritis of the pig (hog-cholera), when it affects the chronic form; in fact, Roloff described this disease as a scrofulous enteritis. Besides the macroscopic characters, to-day so well-known, which in the immense majority of cases permit one to make the diagnosis 'pneumo-enteritis,' one will find, if it is necessary, in the microscopic examination, in the culture, and inoculation, of the caseous contents of suspected glands, certain means of a very rapid diagnosis.

If one was consulted on the subject of a tuberculous pig, it is quite certain that the clinical signs alone would rarely allow one to make the diagnosis. The injection of tuberculin would be the surest and most rapid way out of the difficulty, for in the tuberculous pig, as in the tuberculous cow, the reaction set up by tuberculin is specific and characteristic. The dose for injection varies from 10 to 25 centigrammes, according to the weight of the animal.

Progress of the Disease.—It is generally admitted that tuberculosis of the pig is rare, principally because in this

animal the disease assumes the acute or galloping form, and as a result the affected animal succumbs rapidly before it has been able to scatter round it the germs of the disease.

Though this is the rule, there are numerous exceptions to it. During the last few years I have collected more than thirty observations of scrofula or chronic tuberculosis in the pig. The disease has always presented the same appearance—massive lesions, rather thinly scattered, rich in giant-cells, very poor in bacilli, so poor, in fact, that sometimes it has been necessary to carefully examine four or five sections before meeting with any. But inoculation of the suspected products into the peritoneal cavity of guinea-pigs soon shows that we are dealing with true tuberculosis—not that the guinea-pig succumbs rapidly; on the contrary, I have seen them hold out three to four months and longer, but even those which seem well are attacked by severe visceral lesions, and, if they are killed five or six weeks after the inoculation, the spleen, the liver, and sometimes the lung, are stuffed with big nodules, few in number, in the centre of which it is possible to find a few of Koch's bacilli. The passage of the disease through a series of animals by inoculation from one to another produces effects similar to those which I have indicated with regard to scrofula of man; the more often the transmissions have been made, the more rapidly death supervenes. The lesions become more minute, more confluent, and also richer in bacilli, and, when one has recourse to intravenous inoculation, the rabbits, after the fifth or sixth transmission, die in twenty to twenty-five days from a veritable tuberculous septicæmia, and the spleen, the medulla of the bones and the liver, although they do not show nodules visible to the naked eye, are crowded with myriads of

tuberculous follicles, which are incredibly rich in Koch's bacilli.

Whatever be its origin, the bacillus of porcine tuberculosis is always the same, and always identical with the bacilli of the tuberculoses of the other mammalia. The cultivations and inoculation of the guinea-pig prove this conclusively.

French sanitary law does not apply to tuberculosis of the pig. The regulations of most abattoirs, however, prescribe the seizure of tuberculous pigs. It is fortunate that they do so, because in the pig the disease seems to become generalized much more readily than in other animals, and the result of the known experiments on the subject is to show that the muscle juice of the tuberculous pig is very often virulent. The danger which it presents is so much the more increased by the fact that much of the pork-butcher's meat is consumed without being previously cooked.

If, then, the inspector of butcher-meat ought to be very indulgent in the case of tuberculous cattle, he ought to be very strict with regard to tuberculous pigs.

CHAPTER III.

TUBERCULOSIS OF THE HORSE.

TUBERCULOSIS of the horse is a disease which is relatively very rare. Nevertheless, during the last fifteen years, a sufficient number of instances of it have been published to enable one to attempt to describe the principal forms which it assumes.

In the horse the disease may be localized either in the organs of the abdominal cavity, or in those of the thoracic cavity. It begins sometimes in the former, sometimes in the latter, and then becomes general, but most frequently it is by means of the digestive tract that the infection effects its entry.

Curiously enough, all the cases hitherto observed have been isolated ones, in spite of the fact that the affected animal, as a rule, belonged to a large stud. The explanation of this appears to be, firstly, that the lesions usually develop first in the organs of the abdominal cavity, the lung being only attacked secondarily and at a later stage; and, secondly, that a horse which is no longer able to do any work is not generally kept for any length of time, but is killed. The tuberculous horse rapidly becomes unfit for work, so that the pulmonary lesions, when present, have not time to undergo the softening necessary to produce the nasal discharge or virulent expectoration which constitute the most potent agents of infection.

Although it is certain that the intestinal tract is the principal entrance-gate for the bacillus, nothing precise is known as to the origin of the contagion. Lehnert has published an interesting case of a foal which became tuberculous as the result of a long stay in a stable with some phthisical cows.*

Lesions.—The lesions which are found at the autopsy of a tuberculous horse are usually very different from those which we have studied in the cow and in the pig.

1. Most frequently, as we have said, the disease begins in the organs of the abdominal cavity. It attacks the glands especially, the spleen, the liver, the peritoneum, and sometimes the intestine. Almost always, too, it attacks the lung, but secondarily.

On opening the abdomen, a variable quantity of yellow and transparent, or reddish and grumous, liquid always flows out.

The peritoneum sometimes is studded with smooth, firm, gray-pink or whitish, small rounded tumours, about the size of a millet-seed, a pea, or a hazel-nut.

The sublumbar glands are generally transformed into an enormous tumour, which may extend from the diaphragm to the pelvis, surrounding the aorta, the vena cava and the kidneys. The tumour is irregular and knobby, and presents, on section, a smooth succulent white surface crossed by gray veins, which is sometimes uniformly tough and resistant, but more frequently softened and caseous in places. The glands of the concave border of the intestine are generally very large and white or gray-pink in colour, sometimes homogeneous and succulent and firm, sometimes completely caseous.

The spleen is generally enormous, and enlarged in all

* *Sachsen Jahresbericht*, 1888.

its dimensions. It is stuffed with round, white, firm, succulent, rarely caseous tumours, of a size varying from that of a hazel-nut to that of an apple. Its tissue is firm, and when it is cut into, the glomeruli of Malpighi are seen to be greatly enlarged; they are as big as peas, and their pale-pink colour shows up well against the brown-red background of the organ.

The liver is always very large, and is sometimes infiltrated by tumours like those of the spleen. On section, the surface is often seen to be crossed by delicate grayish-white veins, which define the lobulation of the organ very distinctly; this is due to an interesting form of portal cirrhosis.

The intestine is fairly often the seat of important lesions, which are especially found in the Peyer's patches of the ileum. Sometimes the lesions consist of actual thick tumours, which are flabby and red and have a fairly smooth surface. Sometimes the tumours are ulcerated, and the floor of the ulcer contains a yellowish or blackish, very fœtid, pulpy material. Sometimes, lastly, there only exists at the site of the patch an ulcer, the depth of which is increased by the indurated thickening of the mucous membrane at its periphery.

The lung is nearly always infiltrated by lesions, which are obviously more recent than those of the abdominal organs. It is very large and heavy; nevertheless it floats in water, and is still supple, elastic and firm. When cut, it gives the sensation of a tough, slightly indurated, tissue. The cut surface has the following appearance; on a uniformly vivid-red background appear a multitude of dirty-white markings, which are irregular, and branch and anastomose so as to give the organ an irregular lobulation; this abnormal new tissue is homogeneous, and has the same appearance throughout the

whole of its depth; in no part of it are there nodules with tough fibrous walls, or cavities, or foci of softening, and, in fact, one would say that it consisted of an irregularly-distributed diffuse infiltration of the interlobular connective tissue. All these lesions are extremely rich in the specific bacilli, which always seem to be a little longer than in other animals. We have seen, however, that inoculation in the guinea-pig and cultures show that they are identical with those met with in the other mammalia.

2. Sometimes the disease begins in the lung. The lesions are then very variable. (1) Sometimes they consist of rounded nodosities, as big as a hemp-seed, a pea, or a hazel-nut, distributed with a fair amount of regularity throughout the substance of the organ; these small tumours are composed of collections of soft caseous material, very rich in bacilli, surrounded by thick tough fibrous walls. (2) At other times the lesions resemble sarcomatous or carcinomatous growths, generalized throughout the lung; these growths are white, tough, homogeneous throughout, devoid of areas of softening, of a size varying from that of a hazel-nut to that of a walnut or a pigeon's egg, and do not set up irritation of the pulmonary tissue, which preserves its normal appearance in their immediate neighbourhood; they consist of collections of a great number of tuberculous follicles, have no tendency to caseation, and are very rich in giant-cells and very poor in bacilli. (3) Lastly, the disease sometimes consists of a more or less extensive true caseous pneumonia, with bronchial dilatations and cavities as the result of the progressive softening of the caseous tissue.

In all these cases the bronchial glands are attacked early. They are hypertrophied, and either stuffed with

miliary nodules or, as is more frequent, caseous and softened.

Sometimes, also, the pleura and the pericardium are attacked by more or less severe tuberculous lesions. These lesions consist either of miliary nodules, which are isolated or in clusters, grayish or whitish, rather tough and always small, or else of a considerable thickening of the serous membrane, which seems to have undergone a true caseous infiltration.

There may be also found variable lesions of the tonsils, of the lymphatic glands (submaxillary, pharyngeal, superior and inferior cervical, etc.), of the kidneys, of the uterus, of the mammæ, of the myocardium, etc. In addition, ulcerations of the bronchi, of the trachea, of the larynx, and even of the nasal cavities, have been described.

It is important to note that tuberculous lesions of the horse very rarely become calcified.

Symptoms.—The predominant symptom, in most of the cases that have been observed, has been inability to work, at a time when nothing else in the general state of the animal seemed to indicate that it was ill. It is quickly out of breath, and, on the least effort being required of it, soon stops, and, with heaving flanks, head extended and nostrils dilated, its limbs trembling, it refuses to go on. The most careful examination of the principal systems fails to discover any lesion capable of explaining this loss of power.

Soon rapid wasting supervenes, in spite of a good appetite and good food. At the same time profuse polyuria usually comes on, and persists for several weeks, and undoubtedly plays an important part in the rapid wasting of the subject. Not only is the quantity of the urine excreted increased to double, triple, or quadruple

the normal, but changes in its composition also take place. The proportion of urea is greatly increased. Uric acid, which is normally absent from the urine of herbivora, is found in relatively large amount, whilst hippuric acid, usually so abundant, is present in very small amount, or is absent altogether. Briefly, the urine of a tuberculous horse is that of an animal which is devouring its own flesh, and indicates rapid consumption of the organism.

I have noticed this polyuria in all the eleven cases of abdominal tuberculosis which I have personally observed, and I attach to it a diagnostic importance of the first rank.

All these signs become rapidly more pronounced: the animal falls into a state of marasmus; it is only able to stagger along; its appetite becomes capricious and fails altogether; the fever becomes constant, the temperature often being higher in the morning than in the evening, but hardly ever rising more than one or one and a half degrees above normal. At this period the quantity of urine excreted may become normal, and it sometimes contains a small quantity of albumen. At this period, also, auscultation reveals some harshness of the vesicular murmur, which is, however, everywhere retained, and sometimes here and there a little crepitation at the end of expiration. The resonance on percussion is everywhere normal, or very slightly diminished. The heart may show slight functional disorder; the first sound is duller, and sometimes reduplicated; the second sound is sharper and more distinct. From time to time a slight pulsation in the veins shows the difficulty which the ventricle has in driving forward the blood which distends it. There is nothing very significant, in fact, about any of these signs.

Towards the close of the disease, congestion of the limbs and profuse diarrhœa may supervene. All these signs are specially noticed in *abdominal tuberculosis*, which is the most common form of the disease, and has been the most studied. Rectal examination often increases the probability of the diagnosis by revealing the presence of a bulky tumour in the sublumbar region.

In the *pulmonary form* of the disease a cough is nearly always present—a cough which is generally short, dry, paroxysmal, and painful. The cough is usually accompanied by a small amount of mucous discharge from the nostrils. This discharge is seldom abundant or purulent, since, for that to occur, the pulmonary lesions must undergo caseous softening, and become transformed into actual cavities communicating with the bronchi. Excepting in the very rare cases where this latter occurrence has taken place, the examination of the lung gives but little more information than it does at a late stage of abdominal tuberculosis.

However, when the pleura is attacked, a more or less copious effusion may take place, which will reveal itself by the ordinary signs of hydrothorax. There have also been described more or less frequently repeated nasal hæmorrhages, and specific congestions of the external glands, such as the subglossary, parotidian, prescapular, etc.

Diagnosis.—The diagnosis of tuberculosis of the horse does not seem very difficult. Five times I have been able to make the exact diagnosis—abdominal tuberculosis. The feebleness, the shortness of breath, the progressive wasting, the condition of the urine, and the finding of a bulky tumour in the sublumbar vault, are characteristic. In the pulmonary form the cough does not constitute so important a sign as the sublumbar tumour in the

abdominal form ; but if there is any discharge from the nostrils, the microscopical examination and inoculation of it will enable one to make a certain diagnosis readily enough.

In the case of a pleuritic effusion, there comes the question whether the lesion is due to glanders or tubercle, and here again inoculation is the most certain means of deciding. In such a case the inoculation should be done by injecting into the peritoneal cavity a large quantity of the liquid, 2 cubic centimetres at least, preferably 5 or 6.

Lastly, the injection of tuberculin is of the greatest use in doubtful cases. A dose of 30 to 40 centigrammes, according to the size of the subject, must be injected.

CHAPTER IV.

TUBERCULOSIS OF THE SMALL RUMINANTS.

THE sheep and the goat are very rarely tuberculous under the natural conditions of their existence, but they can be given tuberculosis experimentally. Although they usually resist subcutaneous inoculation, and even intra-ocular injection, intravenous injection sets up in them an acute miliary tuberculosis, which is rapidly fatal. The repeated ingestion of tuberculous material rich in bacilli also succeeds in infecting them.

The description which has been given of pulmonary phthisis in the sheep by Hurtrel d'Arboval, Dupuy, Delafond, etc., does not enable one to know exactly with what affection they were dealing; probably it was a broncho-pneumonia caused by worms, which is so frequent and so severe in damp years, and which bears such a strong resemblance to the caseous pneumonia of human phthisis, that M. S. Colin has named it 'phthisie vermineuse." In this affection one sees, side by side with extensive foci of diffuse pneumonia, nodules, apparently tubercular, of the size of a millet-seed or a pea, which are yellow-gray and semi-transparent, and the consistence of which diminishes from the centre to the circumference. These nodules may assume a caseous character, and may even undergo calcareous infiltration; most of them occupy the peri-

phery of the lung, and especially the fringes of the lung, and many of them are situated immediately under the visceral pleura (Neumann).

The most simple microscopic examination of the liquid obtained by scraping a section shows the eggs or the embryos of *Strongylus rufescens*, and allows one to attribute these lesions to their proper cause.

It seems highly probable, however, that prolonged cohabitation with tuberculous cattle would succeed in transmitting tuberculosis to some sheep.

In Saxony, for instance, where bovine tuberculosis is so frequent (18·26 per cent.), out of 85,701 sheep slaughtered in 1891 in the inspected abattoirs, 30 were found to be tuberculous, or ·035 per cent. In 1892 the proportion remained the same: 39 tuberculous out of 104,987 slaughtered. In 1893 the proportion increased: 125 tuberculous out of 108,407 slaughtered, or ·11 per cent.

Again, out of 916,662 sheep slaughtered in the public abattoirs of Prussia during the administrative year 1892-93, 884 were found to be tuberculous, or ·09 per cent. One must admit that about half of these statistics had reference to cases of true tuberculosis.

Some observations of tuberculosis in the goat, not caused experimentally, have been published, although as a rule verification by the bacillus or inoculation was wanting; yet in some cases the diagnosis seems to have been correct.

Carsten Harms found, at the autopsy of an emaciated goat, pulmonary nodules and cavities, which he attributed without any hesitation to tuberculosis. The nodules were from the size of a millet-seed to that of a pea; on section some of them were gray and shining, but most of them were yellow and dull. The size of the cavities varied from

that of a hazel-nut to that of a pigeon's egg; their walls were smooth, and the cavity of some of them was crossed by bands.

Gerlach has published a similar observation. Lydtin states that he has observed tuberculosis in three goats quartered in a stable with cows, several of which were affected with 'pommelière': the sick goats grew gradually thinner, and coughed; their mucous membranes became pale; the secretion of milk became diminished to such an extent that the animals, being no longer profitable, were slaughtered. In these three goats the lesions were localized in the pulmonary tissue and the pleura. The two cases of Motz and that of Van der Sluys and Korevaar also had reference to goats which had lived with tuberculous cows.

Detroye observed, at the clinic of the school at Lyons, in 1882, a milch goat which wasted rapidly, had a cough, and frequently suffered from gaseous distension; its milk also ran dry. At the autopsy there was found pleurisy, and in the lung numerous, mostly caseous, nodules, and a cavity as big as a hen's egg, with irregular, sacculated walls, containing an inodorous, greenish-yellow, grumous material; the mesenteric glands were enlarged to the size of a billiard-ball or a hen's egg, and on section appeared to consist of a rather thin fibrous envelope, enclosing unsoftened tuberculous material. As there seemed to be no doubt about the diagnosis, histological examination and inoculation were not resorted to (unpublished communication).

At the second congress on tuberculosis, Thomassen read the notes of the autopsy of a fifteen-months-old goat, which had been reared from its birth on the milk of a cow which was very probably tuberculous. The goat had miliary tuberculosis of the lungs, liver, and spleen, the

thoracic and mesenteric glands were enlarged and caseous, the mucous membrane of the small intestine was covered with ulcerations. The examination of the discharge from the nostrils and of the lesions showed an abundance of Koch's bacilli.

E. Alston's case was that of a three-year-old goat which had been slaughtered on account of extreme emaciation. The substance of the lung was studded with grayish-yellow foci; the bronchial glands were enormous. MacFadyean's examination showed the bacillary nature of the lesions (*Journ. of Comp. Path.*, 1892).

In König's case, that of a milch goat, the lungs, liver and mesenteric glands were riddled with tuberculous nodules.

In Moule's case, which was that of the carcase of a goat sent without the viscera to the auction market, a thick fibrous layer, infiltrated by calcareous or softened tuberculous nodules, was found on the costal pleura.

In conclusion, Siegen has observed, at the Luxemburg abattoir, ten tuberculous goats.

From all that has been said, it will be evident that, although the sheep and the goat may become tuberculous independently of experimental conditions, the occurrence of such a thing is exceptional. Nevertheless, as children are often reared on goat's milk, the most elementary prudence demands that a goat used for this purpose should be previously tested with tuberculin.

CHAPTER V.

TUBERCULOSIS OF THE DOG AND CAT.

The carnivora, the dog more particularly than the cat, have long been considered refractory to tuberculosis; they usually withstand subcutaneous injections, but they succumb with certainty to the intravenous injection of a small quantity of a culture, or of a tuberculous product of a mammal. (The dog withstands the injection of large quantities of cultures of tuberculosis avium.)

We have seen that the kitten easily becomes tuberculous when fed on tuberculous milk or viscera; the younger the animal, the more apt it is to contract tuberculosis. In one of my experiments, four kittens, six weeks old, and their mother received a paste with which had been mixed a very abundant culture of the tubercle bacillus. All the animals participated in the repast. Whilst the four kittens died (as is usual) in a time varying from six weeks to four months, the mother remained vigorous and well, but had, however, tuberculous lesions of the spleen, liver and lung, as was shown by the autopsy made several years afterwards.

Independently of experimental conditions, the dog and the cat may become tuberculous. Since attention has been drawn to this, so many cases have been recorded that veterinary literature contains at the present time several hundreds (Bang, Jensen, Cadiot, etc.).

Authentic cases of tuberculosis in the lion, the tiger, the panther, the jaguar, the fox, the jackal, etc., have also been reported.

In most of the cases of tuberculous dogs, the animals belonged to and lived with tuberculous people, and seem to have been infected either by the ingestion of sputa, vomited matter, or leavings of food, or by the inhalation of virulent dust resulting from the drying of the sputa. In some cases the dogs have been obviously infected, either at home by raw milk or at the abattoir by tuberculous viscera.

If the dog can become tuberculous from contact with man, the converse is equally true. Infection is at any rate possible when a house dog scatters on to the floor, carpet, or bed during its fits of coughing virulent material, which is rendered extremely dangerous by drying, especially for the children, its habitual playmates. The most elementary prudence would recommend the banishment from a room of every dog which coughs frequently, even although it only seems to be suffering from some common affection of the bronchi or lung.

Lesions.—The lesions of tuberculosis of the carnivora are eminently variable. They may attack all the organs. Except in cases of generalization, it is rather rare for them to take the form of miliary granulations. I have several times seen them localized exclusively in the lymphatic glands of the thorax or abdomen; these glands then formed enormous tumours, usually excavated by spaces filled with a serous, milky, or purulent liquid, the tumours, equal to a hen's or turkey's egg in size, encircling and compressing the trachea, bronchi, œsophagus, nerves, and great vessels.

Most frequently the lesions are situated in the lung, where they show themselves as more or less extensive

foci of caseous broncho-pneumonia, sprinkled with small cavities resulting from the dilatation of bronchioles or the progressive ulceration of caseous tissue.

Often also the spleen, liver, kidneys, and even the heart, are occupied by tough whitish tumours, varying in shape and size, and having a sarcomatous appearance, which the bacteriological examination shows to be due to the bacillus of Koch.

The serous membranes also may be occupied by variable lesions. In some forms with ascites, the puncture of which lets out a large quantity of limpid or slightly yellow serous liquid, there are often found on the mesentery and parietal peritoneum thousands of small tumours, which are rounded or flattened, white or opalescent in colour, and of the size of a millet-seed or a pea. In other cases the serous membrane is the seat of a considerable thickening, which has a smooth surface with rounded or mammillated projections on it; and on section the tissue is whitish, dense and firm, not crumbling, but brittle. Similar lesions with the same appearance, either tumours or infiltrations, are found on the visceral or parietal pleura in certain forms of hydrothorax. The pericardium is also sometimes the seat of a similar change, which is always accompanied by a more or less considerable effusion into the sac.

In case of generalization, the cerebral pia mater may be covered with semi-transparent grayish granulations, which transform it into a kind of veil studded with tiny pearls.

The intestine is rarely attacked by the specific lesions, but I have met with one good specimen in a kitten. The mucous membrane of the small intestine was covered with tuberculous ulcers, one of which had perforated the intestine and set up fatal peritonitis.

Signs and Diagnosis.—The most constant symptoms are those of a rapidly progressive cachexia. In spite of plenty of good food, the animal gets continually thinner. It is low-spirited, and easily gets out of breath. It remains continually lying down, and has a miserable appearance. The atrophy of the temporal regions and the retraction of the eyeballs give to it the physiognomy so characteristic of old cancerous dogs.

To these general symptoms are added those due to the particular situation of the lesion ; the paroxysmal cough, frequently followed by vomiting, the purulent discharge, and the hurried, panting, difficult breathing, are the signs most often noticed. In young dogs one might think one had to deal with catarrhal broncho-pneumonia, which is a frequent complication of the disease. Examination of the discharge makes the diagnosis easy, as it swarms with tubercle bacilli. Ascites, hydrothorax and hydro-pericardium ought always to make one suspicious of tuberculosis, the best method of making the diagnosis being the inoculation of a fairly large quantity of the liquid obtained by tapping.

Glandular tuberculosis always sets up the combination of symptoms which accompany affection of the bronchial glands ; in this case the tuberculous nature of the lesion can only be guessed, there being no products to examine or inoculate. This is the opportunity for tuberculin, which will make the diagnosis of the most difficult cases easy, rapid, and certain. Five to ten centigrammes should be injected, according to the size of the animal. (Healthy dogs stand a dose of 50, 60, and even 100 centigrammes of tuberculin without showing any symptom or feverish reaction.)

Lastly, there are cases where the disease develops so

slowly that it sets up no apparent trouble. It is tolerably common to find, at the autopsy of dogs which have never seemed to be ill, isolated and diminutive tuberculous lesions of the liver, lung, kidneys, peritoneum and pleura.

CHAPTER VI.

TUBERCULOSIS OF BIRDS.

TUBERCULOSIS is a common disease among the birds of the poultry-yard, and makes ravages among them under the form of an epidemic. It attacks poultry, pigeons, turkeys, pea-fowl, guinea-fowl, etc.; and even the small birds take it experimentally.

Lesions.—The lesions are found chiefly and almost exclusively in the organs of the digestive system. The liver is the organ most frequently and most severely affected; it is always greatly enlarged, and crowded with tubercular granulations of varying size. Sometimes it is speckled with white to such an extent that one would think the organ had been sprinkled with fine sand; sometimes the lesions consist of small, hard, white or yellow nodules of the size of a millet-seed or a pea; sometimes they consist of large rounded tumours, which are whitish, fibrous, firm or softened in the centre, and about the size of a hazel-nut, a marble or a walnut (I have often seen them like this in the pea-fowl or the turkey); sometimes they consist of true granulations, which are gray and translucid, and analogous to those of 'granulie.' (This form has seemed to me most common in the pheasant.) Between the granulations the tissue does not seem to be modified, but it is more friable than normal, and ruptures

of the tuberculous liver, causing a fatal hæmorrhage, are fairly common among fowls.

The spleen is nearly as often affected as the liver; it is generally infiltrated by very fine, whitish granulations, but sometimes it contains true tubercular nodules, which are hard, calcareous, and agglomerated into irregular masses, occasionally very large.

The intestine is very often invaded; sometimes the lesion consists of a true tuberculous infiltration, involving the serous, muscular and mucous coats, and more or less deeply ulcerated; more frequently it consists of granulations heaped together into such large masses that they may obstruct the intestinal canal.

The peritoneum is fairly often the seat of an eruption of white and firm miliary nodules with smooth surfaces, in which case some ascites will be noticed.

The lungs are rarely affected; when they are, the lesion takes the form of small, whitish, caseous masses, resulting from the agglomeration of miliary nodules.

The joints and the peri-articular tissues are sometimes the seat of tumours of a tuberculous nature, which are firm or softened, ulcerated or fistulous.

Again, it has been recently shown that certain lesions of the mouth, pharynx, frontal sinuses, nose and conjunctiva, which were formerly attributed to diphtheria avium, swarm with tubercle bacilli.

Finally, there are certain horny tumours of the skin of the face, head, neck, or feet, which must be assigned to tuberculosis, since these horny growths contain considerable numbers of the bacilli.

Whatever be the position or form of the lesion, it is always extremely rich in bacilli. They are found in tufts or felted masses, sometimes so thick that they conceal the arrangement of the anatomical elements.

These bacilli generally seem a little longer than those met with in tuberculous mammalia. Otherwise, they have the same characteristics, react in the same way to the same stains, and flourish on the same culture media. As a general rule, the bacillus of tuberculosis avium seems more vigorous; it makes a longer resistance against natural causes of destruction; it grows more quickly and more abundantly, other things being equal; it grows at 43°C., a temperature which arrests the growth of human tuberculosis; its cultures on solid media have less consistence, are softer and more greasy, and spread out easily, being less tightly packed. These differential characters are so constant and so marked that they explain why there has been a desire of late years to regard tuberculosis avium as a disease absolutely distinct from, and bearing no relation to, human tuberculosis. We shall see presently what to think of this.

Symptoms and Diagnosis.—The symptoms of tuberculosis in birds are extremely vague. The most striking one is the progressive wasting of the subjects. The breast-bone, when it is examined, is found to be very sharp, owing to the wasting of the pectoral muscles. The animals are less lively, as it were listless; the crest is flabby and pale, and they die with the cachexia well marked. In a poultry-yard which is known to be infected, these signs are sufficient to point out the tuberculous subjects, but they would be quite insufficient to make the diagnosis in an isolated case.

It may happen that the animal limps, and in that case examination of the limb will perhaps reveal an articular swelling or an ulceration, the pus from which contains numerous bacilli. In such a case the diagnosis is easy, even in the living subject.

The post-mortem diagnosis is very easy. One only has

to crush a morsel of the affected liver, spread it out between two cover-glasses, and stain by the method of Ehrlich or Ziehl, to show the specific bacilli, which are generally present in considerable numbers.

Etiology.—When a poultry-yard is infected, the disease perpetuates itself in a hopeless manner. Restocking, after killing all the contaminated animals, is not sufficient to drive it away, unless all the places and utensils used by the poultry have been previously thoroughly disinfected.

In most cases, tuberculosis appears in a poultry-yard after the importation of new purchases. Those which undoubtedly came from an infected poultry-yard become sick more or less rapidly, grow thin, and die. Other animals become sick in their turn, even among the old inhabitants, and the disease may thus perpetuate itself in the poultry-yard, attacking a third, a half, or three-quarters of the fowls. Infection always takes place by the digestive tract. The excrement of most of the sick animals contains great numbers of bacilli, and the healthy birds, going about incessantly picking, in this way infect themselves by the continual ingestion of virulent material. Moreover, experiments show that if a fowl is made to eat a small quantity of the liver of a tuberculous fowl, it dies in a few months with lesions exactly analogous to those of tuberculosis acquired in a natural manner.

Intraperitoneal inoculation gives identical results. Subcutaneous inoculation sometimes only causes a local tuberculosis, without any effect on the general health of the animal. The intravenous injection of a filtered dilution of tuberculous material or of a culture kills the fowl experimented on with certainty in a few weeks. At the autopsy the liver and spleen are found to be excessively enlarged in all directions, congested, and friable; and

bacteriological examination shows that they are literally crowded with myriads of microscopic tuberculous follicles, which are extremely rich in bacilli.

The importation of an affected fowl is not the only cause of the appearance of the disease in poultry-yards. There are a considerable number of well-authenticated cases on record, in which it seems evident that the birds have been infected by means of the purulent sputa of the persons employed to look after them. Again, tuberculosis has been observed in fowls reared in abattoirs, where they have been fed on contaminated meat and tuberculous viscera.

The results of experiments are opposed to these cases of observation. Certainly one does not usually succeed in transmitting to fowls the tuberculosis of man or the mammalia, either by inoculation or by ingestion. Straus and Wurtz made six fowls eat formidable quantities of the sputa of consumptives, and none of them became tuberculous. I have repeated this experiment, also without success, taking the material to be ingested from tuberculosis of the cow, the horse, and the pig.

But do we realize experimentally all the conditions of the natural infection ? Let a single animal in a large poultry-yard allow itself to be attacked by bacilli, coming from man or cattle, then these bacilli, acclimatized to the organism of the fowl, will be transmitted with greater ease to other fowls in the yard.

Rivolta, Mafucci, Straus, Gamaleia, and most experimenters, have failed to transmit tuberculosis of the mammalia to birds. All have noted that the guinea-pig generally withstands subcutaneous inoculation of tuberculosis avium, and that, if it succumbs to intraperitoneal inoculation, the lesions are very different to those set up by human tuberculosis. The spleen is enormous, red, and

soft; it, as well as the liver and lung, rarely shows tubercular nodules, but the spleen and liver are crowded with microscopic tuberculous follicles, which are very rich in bacilli.

These observers have also found that the dog withstands intravenous inoculation of large quantities of cultures of tuberculosis avium.

On the other hand, Cadiot, Gilbert and Roger, Courmont and Dor, and myself, have shown that the inoculation of the tuberculosis of the mammalia into fowls is sometimes successful, and that this tuberculosis can then be transmitted by inoculation from one fowl to another. Also, although it is true that the lesions observed in the guinea-pig, as the result of the inoculation of tuberculosis avium, are widely different in appearance from those observed after the inoculation of human tuberculosis, yet sometimes only a few transmissions from guinea-pig to guinea-pig are all that is necessary to enable these lesions to reproduce the type so well described by Villemin. Lastly, it must be remembered that the rabbit has an equal receptivity for the two forms of tuberculosis, and that, after two or three transmissions from rabbit to rabbit, the lesions are so identical that it is impossible to distinguish the origin of them.

All these facts tend to establish that the tubercle bacillus, so resistant to all the causes of destruction, may, however, experience profound modifications by means of successive passages through the organism of divers species of animals. But if the modifications which it undergoes as the result of numerous transmissions through birds are profound enough to make the bacillus of tuberculosis avium a peculiar variety of the bacillus of Koch, they are not enough, in my opinion, to make these bacilli two distinct species.

A last argument in favour of the identity of these bacilli might be derived from the identity of their products of secretion. Whatever be the origin of the sowing, it is impossible to notice any appreciable difference either in the mode of action or in the activity of the tuberculin obtained from the different cultures of the tubercle bacillus.

Prophylaxis.—The only prophylaxis applicable to tuberculosis of poultry is to kill absolutely all the birds of the infected yard, to subject to thorough and repeated disinfection all places and utensils used by the birds, and to restock the yard with birds from a source that is above suspicion. Sulphuric acid (50 grammes to the litre), carbolic acid, créoline, lysol (3 per cent.), may be with advantage used as disinfectants, after thoroughly scraping out all places impregnated with excrement.

It is not a question, be it well understood, of selling the animals which still appear to be in good health. These animals, which may be contaminated, would in that case infect the poultry-yards of their buyers. This is then a matter of simple honesty.

The birds must be killed and consumed on the farm, as they may be wanted. It would not be honest to let people eat them who were ignorant of the possibility of danger, and would perhaps not take sufficient care to cook them thoroughly. We know that usually tuberculosis avium is difficult to inoculate into certain mammalia, such as the guinea-pig, the dog, the sheep, and the horse, but that the rabbit, on the other hand, has a great receptivity for it. How does it act towards man? We do not know. But the possibility of danger must be admitted and guarded against. On the farm itself the animals may be consumed without risk, for it will be sufficient to take out and destroy the viscera and to cook the meat well.

If it is a question of birds which are valuable for some reason or other, one might apply the tuberculin test rigorously, and only kill those which gave the diagnostic reaction. The test would have to be repeated after a few weeks, and it would be necessary to redouble the care taken in the disinfection of the hen-houses, etc., before putting back there the sound birds.

The dose of tuberculin for injection varies from 5 to 10 centigrammes for fowls, pigeons, or pheasants, and from 10 to 20 centigrammes for geese, turkeys, and pea-fowl.

TRANSLATOR'S APPENDIX.

THE object of Professor Bang's scheme is to gradually eliminate tuberculosis from a herd of cattle without having recourse to the heroic method of destroying all the affected animals, and a description of the scheme was given by him to the Society of Danish Veterinary Surgeons in June, 1894, and to the Congress of Hygiene at Buda-Pesth in 1894.

The scheme is based on the facts that contagion plays the principal part in the spread of bovine tuberculosis, that the calves of tuberculous cows are almost invariably born healthy, and that tuberculin is a most reliable agent for the detection of the disease.

To begin with, the whole herd is tested with tuberculin, and thus divided into a healthy and a tuberculous section.

The two sections are then separated from one another, and have separate attendants. The healthy section is tested every six months with tuberculin, and any animals which react are at once removed to the tuberculous section.

Those animals of the tuberculous section which are obviously affected are got rid of; but those which are apparently healthy are kept and used for breeding purposes as long as may be convenient, and, as they will

generally be fattened for slaughter before the disease is far advanced, the total condemnation of their carcases as butcher-meat will not as a rule be necessary.

The calves of the tuberculous section are removed to the healthy section immediately after birth, and are fed for the first day on colostrum which has been heated to 65°C., and subsequently on boiled milk.

At first, these calves were kept in separate boxes, and only added to the sound section when they had successfully undergone the tuberculin test ; but Bang thinks now that they may with safety be removed to the sound section immediately after birth, and wait till the time of the general half-yearly testing to undergo the trial with tuberculin.

The following is a brief account of the results obtained by Bang at the farm of Thurebylille, in Zealand :

In May, 1892, the entire herd, consisting of 208 animals, was tested with tuberculin. Although the animals seemed healthy, and there had been no special amount of infection suspected, 80 per cent. of the milch cows and 40 per cent. of the bulls, heifers, and calves reacted.

While the herd was out at grass, the two sections being kept apart, the byre was thoroughly disinfected, and divided into two parts by a wooden partition covered on one side by felt. A separate staff was told off to look after each section, with orders not to go from one to the other.

It was decided to test the healthy section twice a year, and the calves of the tuberculous section as soon after birth as possible.

In October, 1892, the healthy section consisted of seventy animals, of which seven reacted and were removed to the tuberculous section.

In May, 1893, the healthy section consisted of 103 animals, of which ten reacted and were removed to the tuberculous section. After this the isolation of the two sections was enforced more rigorously.

In October, 1893, the healthy section consisted of 107 animals, of which one reacted.

In May, 1894, the healthy section consisted of 122 animals, of which two reacted.

In October, 1894, the healthy section consisted of 119 animals, of which one was suspicious.

In May, 1895, the healthy section consisted of 136 animals, of which none reacted. The tuberculous section at this time consisted of sixty-nine animals.

The few animals bought during these three years were tested with tuberculin before being introduced into the herd.

Most of the calves born during this period were the calves of tuberculous cows, but none of them have developed tuberculosis, with the exception, perhaps, of one calf, which, when tested at the age of six and a half weeks, in November, 1894, gave a reaction.

These results seem to show that a healthy stock may be bred from a tuberculous stock by the simple precautions of separating the healthy from the infected animals, and boiling the milk of the tuberculous cows.

THE END.

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