O N
THE TRANSMISSION OF TUBERCULOSIS
TO MAN FROM DOMESTIC ANIMALS BY THE AGENCY
OF FOOD SUBSTANCES DERIVED FROM THEM:

An historical and critical study, presented to the
UNIVERSITY OF EDINBURGH
As a Thesis for the Degree of Doctor of Medicine

By
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DECLARATION

The material for the following Study, undertaken at the suggestion of Dr Woodhead, was obtained in the Library of the Royal College of Surgeons of England, and from some additional matter supplied by Dr George Fleming, F.R.C.V.S., to whom my best thanks are due.

The Thesis was composed entirely by myself.

26th April, 1892.
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CHAPTER I.
PRELIMINARY.

The problems connected with the transmission of tuberculosis to man from those animals which provide him with food, either as milk or in the form of flesh, are of great interest to the pathologist, and of immense importance to the practical sanitarian.

Looked at from the purely scientific standpoint, these problems are merely a particular case of the general propositions that Tuberculosis is a specific disease propagated by contagion, and that Tuberculosis as it affects man and the domestic animals respectively, is essentially one and the same disease.

To the practical sanitarian, the question presents itself in many important aspects. It is notorious that at least one-sixth of the total deaths in this country are attributed to the results of tubercular processes in one form or other, and any measures that might tend to check this mortality would be hailed with gratitude.

It is the object of this paper in the first place to summarise as nearly as may be in historical sequence (+),

(+). Chiefly the more recent history: the older history will be found in Johne's "Geschichte der Tuberculose" (Deutsch Zeitschr. f. Tiermed. u vergleichende Pathologie 1883) and in Lydtin's "Report" (Archiv. f. Tierheilkunde 1884, translated by Fleming, "The Influence of Heredity and Contagion on the Propagation of Tuberculosis." London.)
and to critically examine the most important evidence which has been adduced as bearing upon the view that tuberculosis may be transmitted from domestic animals to man by means of the milk and flesh of such animals when used as food (+); and secondly to consider how far the evidence so adduced justifies measures being taken by the Authorities entrusted with the care of the Public Health to check such transmission. The evidence falls naturally under two heads: namely, Experimental Evidence and Clinical Evidence.

The Experimental Evidence is of two kinds. (1) In the first we have Inoculation Experiments, in which the suspected materials are introduced into the experimental animal by hypodermic, intraperitoneal or intravenous injection. These experiments are of the greatest scientific interest, having for their object the proof of the presence or absence (actual or potential) of the virus in the substances dealt with, but their bearing on the question at issue is indirect. (2) The second group comprises the Feeding Experiments, in which the experimental animals have been fed more or less continuously and more or less exclusively on the suspected materials. Though more liable to fallacy, and more difficult to carry out than experiments of the former class, the results have a more direct bearing upon the subject.

Under Clinical Evidence I have included those accidental or chance cases in which there is reason to believe that to the ingestion of food derived from tuberculous

(+)

It will be taken as proved that human and animal tuberculosis are identical; a contagious disease of which Koch's tubercle bacillus is the specific virus.
animals, certain undoubtedly tubercular manifestations (in man or other animals) can be traced. The great interest of this evidence lies in the fact that it is the nearest approach we have to direct proof of infection of the human subject through ingestion of tubercular material.

In what follows the Experimental Evidence is set forth, first with reference to Milk and its manufactured products, and next as to Meat.

The Clinical Evidence as to these two classes of substances is then stated.

The general bearings of the evidence, and some of the sources of fallacy in connection with the research are next briefly discussed.

Amd a Chapter on Preventive Measures is added, in which some special points are more fully gone into.
CHAPTER II.

EXPERIMENTAL EVIDENCE AS TO MILK AND ITS PRODUCTS.

It is convenient to discuss the aspect of the question as it refers to Milk in the first place: for nearly all authorities are now (at any rate up to a certain point) in agreement as to the possibility of the virulent character of milk from tubercular cows, and as to the advisability of measures being taken to prevent such milk from being sold for human consumption. One outstanding debatable point demands attention: At what stage in the progress of the disease in the cow does the milk become dangerous? and is it dangerous, even in cases of advanced general tuberculosis, unless or until the udder is affected (tubercular mammitis)? And, further, how far does the danger extend to the various manufactured products of milk:—butter, cheese buttermilk, etc.? Lastly, what preventive measures are available capable of destroying the virulence of the milk and products?

At the time when Villemin was attracting attention by his researches, writings and speeches to the virulence and specificity of Tuberculosis, Félizet (+) raised the question whether it be possible that phthisis pulmonalis may not be conveyed from cows to man, and especially to young children, by the agency of milk: he complained that an increasing number of women were tending to free themselves from the duty of suckling, and were feeding their children artificially; and he suggested that a way of solving the

(+): Receuil de Medicin Veterinaire, 1868, p. 48
problem would be found in a careful comparison of the health of infants hand- or breast-fed respectively over a large area. (+)

In 1869, Gerlach (§) published an account of his experiments; he used the milk of a cow between 7 and 8 years old, suffering from tuberculosis in an advanced stage: the milk was used for three months before death; and the presence of tubercle was proved by autopsy. The animals used were calves (2), pigs (2), a sheep and rabbits (2). One calf died on the tenth day of the experiment (from aphthae, then prevailing): in all the others tubercular disease was found on autopsy: in all cases there was swelling, (and in four there was tubercular degeneration) of the mesenteric glands; miliary tubercle of the lungs; tubercular disease of intestine in two, and in one similar disease in the liver. Gerlach concludes that the milk of tubercular cows is not simply injurious, but is specifically so, that is, it is infectious; and he raises a complaint about the number of tubercular animals found in dairies, which, he aptly says, are the "wet-nurses for many of the children in large towns." (*)

(+). It would seem, however, that such is not the case; there does not appear to be any great difference between breast-fed and hand-fed children with respect to the incidence of tuberculosis: (Gumplowicz; Prag: Med: Woch, 1889, p. 581) But there is no doubt of the great mortality of children under five years old (whose diet is largely cow's milk) from abdominal tuberculosis: the rate (1871-80) was 2.55 per 1000 under 5, more than 12 times the rate for that form of tuberculosis at any other ages. (See Parkes; Brit. Med. Jour, 1888, i. 1847.)


(*) Gerlach repeated his experiments in Berlin with negative results: it was found, however, that there was no tubercle in the cow yielding the milk used:
These conclusions were confirmed by Zürn (+) of Jena, who experimented with pigs and rabbits; and by other observers, notably by Klebs and Bollinger.

Klebs (§) experimented upon guinea pigs, not only with raw milk, but also with filtered and heated milk, endeavouring to determine the nature of the virus, and a possible means of destroying it, rendering the milk harmless. Five animals were fed with the fresh milk of a tubercular cow at intervals, and for periods varying from twelve to forty-two days: - four of them were found (on dying, or being killed) to have tubercular disease. This authority thinks that the process begins with an internal catarrh, followed by tubercular changes in the mesenteric glands, then by similar changes in the liver and spleen.

In another series of experiments, two guinea pigs received each an intraperitoneal injection of the filtrate from a filtered specimen of milk from the same cow, and all became tubercular, leading Klebs to the conclusion that the virus must be in solution. From further experiments he arrived at the further conclusion that heating was not sufficient in all cases to destroy the virulence of the milk; and that this virulence existed from an early period of the disease in the milk-giver.

In the same year (1873) Bollinger(*) published

an important point in connection with this research is that the source of the material must be known and clearly proved diseased. Vide Martin, Revue de Med. 1884, p. 150.


(Ueber Impf. und Fütterungstuberculose)
the first of what has proved to be a valuable series of
researches on the subject, to our knowledge of which he
and his pupils have contributed greatly. This paper
describes the results of inoculation and ingestion experi-
ments with tubercular material upon a variety of animals:
Pigs, calves, a sheep, goats and rabbits were fed with
milk from tubercular cows, and in every case with positive
results in the direction of the production of tubercle.
Two cats fed on the milk remained healthy: (+); and so did
fourteen rabbits, which had been fed on the same milk, pre-
viously boiled.

The next important experimental contribution was made
by Peuch (§) in 1880. He took three young pigs of the
same litter from a healthy mother: the first was fed for
35 days with, in all, about 55 litres (say 1.5 litres per
diem) of milk from a tubercular cow: it was then slaugther-
ed, the intestinal tract and glands were healthy; some tu-
bercular granulations were found in both of the lungs. A
second animal, fed for 93 days, consuming 276 litres of
milk from the same cow, showed, when killed, tubercle in
liver, mesenteric glands, submaxillary glands, and pleura.
The third animal was kept under similar conditions to the
others, but was not fed with the diseased milk: it was
killed at the same time as the second, and was found to
have a granulation in the ileum and four in the lung: it
was subsequently ascertained that the control-animal had
been fed once from a dish contaminated by milk from a

(+)

The receptivity of cats and dogs for tubercle is
feeble. Vide Galtier, Traite des Maladies contagieuses
des animaux domestiques, 2nd Ed: Vpl. ii: p.419...

phthisical cow, hence probably the infection.

A similar series of experiments, made with three rabbits, yielded similar results: one rabbit, killed in 52 days, showing tubercular granulations in the ileum: a second, fed for 30 days, and then allowed to live a further 100 days, became very thin and ill and presented numerous lesions, both granulations and ulcerations. The third (control) animal was absolutely healthy.

Semmer (+) in 1880, proved by intravenous injection that milk (and blood) were capable of conveying tubercular infection to pigs and sheep.

On the other hand Schreiber (§) failed to obtain positive results with 16 rabbits and 3 guinea pigs.

Virchow (*) (in an elaborate paper which will be further considered subsequently) records a case in which the milk of a diseased cow was given to a number of animals (2 calves, 2 goats, 1 sheep, 3 pigs, 2 cats, 4 guinea-pigs), and, after being boiled, to 1 cow and 2 pigs. In one calf, one pig of the first group, and one pig of the second group, general tuberculosis was demonstrated post-mortem, and, had the cow (providing the milk) not been killed, apparently brilliant positive results would have been obtained; but when the cow was slaughtered it was found to be suffering from hydatids and not from tuberculosis. Virchow, however, admits that with a cow proved tubercular by autopsy, the number of affected animals pre-

(*). Berl. klin. Woch. 1880 No.14. p. 189. See also Med. Times and Gazette, 1880, i. 582.
ponderated, and none of the control animals were affected: but his results are described as unsatisfactory and indefinite.

In this paper Virchow denied the identity of human and bovine tuberculosis, an opinion he has since retracted.

Among the first researches made after the discovery of the tubercle bacillus (1882), we have a series of experiments with milk (and fluid from tubercular nodules) by May, (+) who set himself to determine whether the danger of transmission of tuberculosis through the milk of tubercular cows was so great as to be of frequent occurrence: and, if so, could such be rendered harmless by boiling? With strict antiseptic precautions, he used the method of intraperitoneal injections in guinea-pigs, and failed to produce tuberculosis with the unboiled milk from three tubercular cows in, in all, five cases: in one case (2 experiments) it is especially stated that no tubercle bacilli could be found: similar injections (of milk) in a cat and dog gave negative results: fluid from a cavity in a human being produced general tuberculosis in two guinea-pigs and a rat, and also in a guinea-pig when mixed with milk. General tuberculosis resulted, however, in a case where half the mamma was diseased, when the milk was drawn from the apparently healthy as well as from the diseased part. Fourteen injections made with the various samples of milk and fluids, previously boiled, gave, in every instance a negative result. May concludes that there is no very great danger in using the milk of tubercular cows

(+) Archiv. für Hygiene: Vol. i. p. 121. 1883.
as food, so long as the disease is localised; that it is only when the disease is general that the milk is infectious; that when the udder is diseased, the milk is highly dangerous; and that the danger can in all cases be removed by boiling.

Imlach (+) in a Report published in 1884, takes objection to Gerlach's experiments, on the ground that the tubercular lesions developed (in his feeding-experiments) too quickly after ingestion of the material, as quickly, indeed, as after inoculation of the bacillus tuberculosis. He records a long series of experiments made on various animals, with the milk derived from three cows, afterwards shown by autopsy to be tubercular, but free from any mammary disease. In all, three calves, four pigs, a goat, three monkeys and eighteen guinea pigs (4 of them "control" animals) were experimented with; the calves were fed once a day with diseased milk for periods of from two to three months; the pigs and other animals for similar periods: and in every one of the cases the results of the autopsies were negative as regards tuberculosis, with the exception of the monkeys, in two of which the lungs were riddled with cavities, while the third died of cold in five weeks. The extreme frequency of spontaneous tuberculosis among monkeys in this country does not allow the experiments on them to vitiate the general conclusion. Imlach admits, however, that such milk may be injurious to ill fed and ill-clad children whose power of resistance is lowered by frequent attacks of diarrhoea.

An interesting contribution to our subject, from a somewhat different standpoint was made by Martin (+) in 1884. Using the method of intraperitoneal injection, he endeavoured to obtain some idea of the extent of tubercular contamination in the milk sold in the lower class dairies in Paris. He obtained the milk in a sterilised flask, mixed some with an equal quantity of sterilised salt solution, and injected 1 to 2 ccm. into the animals (guinea pigs) used. The milk from thirteen different sources was thus examined, a second animal being inoculated in each case. At the time of his report the results were as follows: -

<table>
<thead>
<tr>
<th>Status</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>3</td>
</tr>
<tr>
<td>Negative</td>
<td>6 ($)</td>
</tr>
<tr>
<td>Probably positive</td>
<td>8</td>
</tr>
<tr>
<td>Probably negative</td>
<td>2</td>
</tr>
<tr>
<td>Still living at time of report</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

Taking the results in those cases only (nine) in which they were indubitable, we find a risk of infection in the proportion of 1 to 3. Two out of the thirteen samples gave positive results beyond question, while three others yielded results probably positive, giving a total of five or about 38.5 per cent: a very high rate, considering the small quantities used and the conditions under which the milk was obtained. Martin justly complains that we punish for adulteration with water and take no no-

(+): Revue de Med. 1884. p. 150
($) Including 2 dead of non-specific peritonitis.
tice, legally, of the far more serious contamination—
tubercle bacilli.

Stein (++) obtained 4 positive results (using the in-
traperitoneal method) in 14 cases: in these 4 cases the
cows were in an advanced stage of the disease.

Johne (§) thought that it is unwise to give milk from
tuberculous animals to young children, and would forbid
the use of milk from udders affected with the disease.

Lydtin, (*) on the other hand, experimenting with
guinea-pigs, using milk from animals with and without mam-
mitis, obtained but a single positive result.

Wesener(++) in a resume of experiments made between
1865 and 1884 with the milk of tuberculous cows, states
that in 86 experiments three fourths of the pigs and half
of the sheep and goats became tuberculous.

Fischer (§§) experimented with milk poisoned by bacilli
from pure cultures; this was given as food to 8 rabbits, and
inoculated into one: one of the former died on the third
day of pneumonia: the others died or were killed in from
5½ to 9 weeks: and all were found tubercular.

At the International Medical Congress at Copenhagen,
(1884) Bang (**) made known the result of his studies on
this question, After referring to the researches of Virchow,
Bollinger, Galtier and Johne, he quotes the opinion of

(+). Exp. Beiträge zu Infect. der Milch perlsuchtiger
Kuhe, 1884.


(*) Archiv. f. Thier heilkunde, 1884.

(++) Krit. u. exp. Beiträge zu lehre von der Fütterungs
Tuberculose, 1884.


446.

(**). Deutsch Zeitschr. f. Thiermedizin. u. vergleich-
ende Pathologie, 1885. xi. 45.
Koch (+) that "before all things it is necessary that the milk should contain the tubercle bacillus, if it is to produce infection. But this appears only to be the case when the udder is itself affected with tubercular disease:" and, he (Koch) adds, "Tubercular nodules are not very often seen in the udder and therefore the milk of tubercular cows has almost no dangerous quality. Both negative and positive results have been obtained in experiments upon animals, depending upon the presence or absence of tubercle bacilli in the milk used as food."

Bang then proceeds to discuss at some length the incidence of tubercular mammitis, and describes its symptomatology, remarking more especially with regard to the latter, that the enlarged udder at first gives a plentiful supply of apparently healthy milk, and that such milk will be freely used as food, although it contains numerous bacilli. This plentiful secretion along with the enlargement of, usually, one quarter of the mamma, Bang believes to be pathognomonic: later on, the milk becomes like yellowish serum and contains little fibrinous flakes, but never, or almost never, becomes purulent. At this stage, the disease is to be distinguished from simple mammitis by the history of prolonged swelling preceding the change in the secretion. There is a short latent period at the outset during which there are probably no bacilli in the secretion.

The milk from the apparently sound part of the udder is shown to be infectious also, producing tuberculosis by

(+) Mittheil: aus dem kaiserl:Gesundheitsamt II. 1884.
inoculation in rabbits. (++)

The pathology of the disease having been described
the author relates some experiments of his own. Five pigs
and three rabbits were fed for some short time with the
milk from two tubercular cows; in every case they contracted
general tuberculosis.

Reverting to the subject at the Congress on Tubercu-
losis (Paris 1888), Bang, (§) again referring to the symp-
tomatology and diagnosis of tubercular mammitis, denies
that the diagnosis is difficult, differing from Nocard
(and from Walley, ( **)Woodhead and McFadyean (x) and others)
He then details the result of a careful series of experi-
ments on twenty one cases of tuberculosis in cows, where
the general disease was advanced, but the mamma was not
affected: 2 c.c. of the milk were injected into the peri-
toneal cavities of a series of rabbits, and in only two
instances was the milk found to be virulent. "This result"
he adds, "I think is sufficiently reassuring. It leads us
to think that the milk of cows affected with tuberculosis
in a less advanced stage, will not generally be found to
contain the virus." A further confirmation of this view
was sought by similar experiments with milk from eight
women suffering from advanced phthisis pulmonalis; in no
case did this milk prove virulent. (++)

(+) In two out of three.
(§) Comptes Rendus de la Congrèes: de la Tuberculose,
p. 69 et seq.
(*) Woodhead's "Bacteria", p. 227.
(x) Ib.
(++) Koubassoff (Comptes Rendus de l'Acad. de Science.
1885 Vol. CI, p. 508) injected tubercular pus into a
pregnant guinea pig, which gave birth to two young
a few hours afterwards: during the first week bacilli
did not appear in the milk, but they were found in the
The general conclusions arrived at are that the milk of tuberculous cows is not necessarily virulent, even in the advanced stage: that the milk from tuberculous animals should always be regarded with suspicion, as one can never tell when the mammary will become affected, and in some rare cases, such milk may be virulent when the mammary gland is apparently free from the disease.

In a further contribution Bang (+) summarises his own results by stating that of 28 tubercular cows, sound as to the udder, the milk of two only gave results pointing to the infectious nature of the milk, and in a very recent communication ($) gives a further total of 63 cows in advanced tuberculosis, the milk from which was virulent in 9 cases only (1 in 7).

Reverting to the Paris Congress of 1888, we find that not much attention was paid to the milk aspect of the question by other speakers. Nocard (†), who had published experiments in 1885 (++) dealing with the point, disposes of the question as settled, stating that the milk is only second week and remained until the death of the animal of general tuberculosis. The young remained healthy.


($) To the Congress of Hygiene, London, 1891. (Nordisk Medicin Arkiv. xxiii, No. 25.) These include three series of experiments.
1. Milk of 28 cows *used* (43 rabbits *viru-* 2 cases
2. " 21 " } to in- (40 guinea pigs *lent *) 4 " 
3. " 14 " oculate 28 " in 3 "

All the cows were highly tubercular, more so than any animals likely to give milk for actual use: and the mamma was actually diseased in three out of the four positive cases in Series 2, but not sufficiently to be diagnosable during life. (†)

(†) Comptes.Rendus de la Congres de la Tuberculose, p. 49

(++) Recueil de Medicin Veterinaire, 30th January 1885.

One positive result (in guinea pigs) with eleven cows.

virulent when the mamma is diseased, but that as the mammaitis is insidious in its onset, the milk of the diseased animals must be suspected.

Galtier (+) comes to similar conclusions warning against exaggerating the danger of infection by milk, and recounting his own researches: on the points especially interesting is that in which positive results were obtained with milk from the slightly diseased mamma of a cow, the blood and muscle-juice of which gave negative results. (§)

The views which were entertained at the Congress are not accepted by Bollinger and his pupils.

Of these Hirschbarger (•) published (1889) a most laborious research, by which he endeavoured to answer two questions. (1) Are the cases in which tubercular cows give virulent milk frequent or rare? (2) Is the milk infectious only in cases of generalised tuberculosis, or is it also infectious in "localised" cases?

The method was as follows: - The udder was obtained directly from the abattoir (one tubercular animal at least being there met with daily) and was carefully removed entire, note being made of the age and condition of the animals, particularly of the extent and stage of tuberculosis in the organs. Any cows found tubercular before slaughter were milked into sterilised glasses. At the laboratory the udder was carefully opened with antiseptic precautions; the milk was drawn into a Pravaz syringe, any contamination

(+): Comptes Rendus de la Congres. de la Tuberculose, p. 76.
(§): Comptes Rendus de l'Academie des Sciences CIV. p. 1444. 1887.
with blood being carefully avoided.

The animals used were guinea pigs, to obtain uniform results on account of the rarity of spontaneous tubercle in them, and because of their ready susceptibility to the artificially induced disease. The injections were made intraperitoneally, the intestinal canal and subcutaneous tissue being avoided. After injection the animals were kept in thoroughly clean hutches about six feet square. There was no septic peritonitis in any case - an evidence of the care and cleanliness employed: and there was no case of death from intercurrent disease; probably to be ascribed to the sanitary condition of the hutches.

The following table gives a Review of the Experiments:
The diagnosis was in every case verified post-mortem by Bollinger himself.

<table>
<thead>
<tr>
<th>No.</th>
<th>Extent of disease in the Cow</th>
<th>Duration of life of guinea pig after injection</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Udder healthy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Confined to thorax.</td>
<td>9 &quot;</td>
<td>Negative.</td>
</tr>
<tr>
<td>3.</td>
<td>Lungs and thoracic wall.</td>
<td>8 &quot;</td>
<td>Extensive tuberculosis of organs and glands.</td>
</tr>
<tr>
<td></td>
<td>Not diagnosed during life.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Lungs and thorax:</td>
<td>9 &quot;</td>
<td>All organs normal.</td>
</tr>
<tr>
<td></td>
<td>Animal in good condition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Extensive tuberculosis</td>
<td>9 &quot;</td>
<td>Tubercles in spleen and omentum.</td>
</tr>
<tr>
<td></td>
<td>in thorax and peritoneum.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animal in fair condition.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disease of pleura and bronchial glands</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Udder healthy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Extent of disease in the cow.</td>
<td>Duration of life of guinea-pig after inoculation</td>
<td>Result</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------</td>
<td>-----------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>7</td>
<td>Thorax only</td>
<td>9 weeks</td>
<td>Negative.</td>
</tr>
<tr>
<td>8</td>
<td>General disease in Thorax and abdomen. Udder healthy.</td>
<td>9 &quot;</td>
<td>Negative.</td>
</tr>
<tr>
<td>9</td>
<td>Early disease in left lung and pleura. (+)</td>
<td>8 &quot;</td>
<td>General tuberculosis.</td>
</tr>
<tr>
<td>10</td>
<td>Limited to lungs and pleura. Animal well nourished.</td>
<td>14 &quot;</td>
<td>Negative. The guinea pig had two healthy young ones six weeks after inoculation.</td>
</tr>
<tr>
<td>11</td>
<td>Advanced disease in both lungs and costal pleura.</td>
<td>14 &quot;</td>
<td>Negative.</td>
</tr>
<tr>
<td>12</td>
<td>Extensive in lungs pleura and diaphragm but only in very small nodules</td>
<td>18 &quot;</td>
<td>Negative. Two healthy young ones born three days after inoculation.</td>
</tr>
<tr>
<td>13</td>
<td>General tuberculosis No tubercle bacilli in the milk.</td>
<td>18½ &quot;</td>
<td>General tuberculosis.</td>
</tr>
<tr>
<td>14</td>
<td>Limited to lung and pleura: animal in very poor condition.</td>
<td>17 &quot;</td>
<td>General tuberculosis.</td>
</tr>
<tr>
<td>15</td>
<td>Both lungs and pleura diseased; in early stage. Animal well-nourished. No tubercle bacilli found in milk.</td>
<td>14½ &quot;</td>
<td>General tuberculosis.</td>
</tr>
<tr>
<td>16</td>
<td>Recent caseous (not calcified) tubercles. Animal particularly well nourished.</td>
<td>16 &quot;</td>
<td>General tuberculosis.</td>
</tr>
<tr>
<td>17</td>
<td>Confined to left lung and costal pleura. Animal in good condition.</td>
<td>10 &quot;</td>
<td>Negative</td>
</tr>
</tbody>
</table>

(+) Milk drawn from this cow at abattoir was carefully examined for bacillus tuberculosis, with negative results.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19.</td>
<td>Limited to thorax. Animal fairly well nourished.</td>
<td>15 &quot;</td>
<td>Negative except a fibrous nodule between the muscles.</td>
</tr>
<tr>
<td>20.</td>
<td>Disease in lungs and liver and the serous coverings of the organs. Animal in very poor condition.</td>
<td>16½ &quot;</td>
<td>General tuberculosis. Some young also affected.</td>
</tr>
</tbody>
</table>

Reviewing these results Hirschberger points out that the infection can have been conveyed to the guinea-pigs only by the existence of the virus—the bacillus tuberculosis or its spores—in the milk (+): but, after extremely careful searching, the bacillus could be found in only one case (no. 18): yet in ten other cases injection yielded positive results: so that either the bacilli were extremely few in number or the virus existed in these cases as free spores. In the case in which the microbe was found, the udder was diseased; and it is suggested that where the udder is healthy, the spores may yet exist in the secretion. And it must not be forgotten that the virus may be temporarily absent.

(+): In some of the experiments two or more animals were kept in one stall, e.g. Nos. 6, 7, and 8, of which No. 6 became affected and Nos. 7 and 8 were not; so Nos. 15 and 16; and Nos. 17 and 18. This is presumptive evidence against contagion from animal to animal in these experiments.
Proceeding to answer his stated questions, Hirsch-berger concludes:

(1) The danger of infection by milk is not only present but is often very great. An infectious character was present in 11 out of his 20 cases, i.e., 55 per cent: and when we consider that, at the very lowest, 5 per cent of our cattle are tubercular, and that, even in an advanced conditions, a litre or more of milk (per day) may be yielded by each cow, the possibility of danger is manifest.

(2) As to the stage of the disease at which the risks of infection are most marked:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>(a) 5 cows in advanced disease gave</td>
<td>4 and 1; or 80%</td>
</tr>
<tr>
<td>(b) 6 &quot; middle &quot;</td>
<td>4 and 2; or 66%</td>
</tr>
<tr>
<td>(c) 9 &quot; early &quot;</td>
<td>3 and 6; or 33%</td>
</tr>
</tbody>
</table>

So that the risk is marked (1 in 3) even in the early stages.

As to the general "condition" (state of nutrition) of the milk-giver:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>(a) 4 cows in very poor condition gave</td>
<td>4 positive (or 100%)</td>
</tr>
<tr>
<td>(b) 7 &quot; fair &quot;</td>
<td>3 results</td>
</tr>
<tr>
<td>(c) 7 &quot; very good &quot;</td>
<td>3</td>
</tr>
</tbody>
</table>

The age of the cow acts only indirectly as a factor, im so far as it influences the extent of the disease.

The general result is that every tubercular cow may transmit the disease; that it is especially apt to do so if the mamma is involved; and that, as a practical corollary, the milk of no cow suspected of being tuberculous should be used as food, until measures have been taken to destroy its possibly infectious properties.
Bollinger, (+) insisting on these results, points out the risk run by children and invalids who drink milk in large quantities and for long periods, imbibing, therefore, large doses of the poison: and the use of such milk plays a prominent part in the causation of tuberculosis in cattle and swine.

Ernst (§) examined microscopically 114 specimens of the milk of 36 cows, and detected the tubercle bacillus in 31.5 per cent of the specimens derived from 10 cows (27.7%) of the 36. The bacilli were found also in the cream, and in the skim-milk. They were pretty evenly distributed both as regards the time of day when the milk was drawn, and also as to the portions of the several yields.

The same observer also records inoculation and feeding experiments.

Of inoculations, 5 out of 49 rabbits, and 12 out of 54 guinea-pigs gave positive results; showing, he says, that 42.8 per cent of the cows gave virulent milk, although no lesion of the udder could be detected by skilled veterinarians. Twelve calves, and seven pigs of one litter, were fed with the milk from the same cows; 5 of the former (41.66%) and at least 3 of the latter (•) (say 40%) became affected.

Following up Hirschberger's research, Gebhart (++)

(§) Practitioner, 1890. ii. p. 143.
(•) 2 negative, 2 positive, 1 hastily examined (probably positive) 2 accidentally thrown away, unexamined
also working under Bollinger, set himself to ascertain how far the risk Hirschberger had shown to exist actually affects the milk of a whole dairy, that is, whether the dilution of a virulent milk with healthy milk, as it would occur in actual practice, can render it inoffensive, and to what extent that dilution must be carried. The method of inoculation was employed and two series of experiments were made.

In the first, ten samples of milk, each bought from a different shop, were employed as a sort of test of the open market at Munich. Two cc. of each were injected into a guinea-pig, and all the cases gave a negative result.

In the other experiments milk was obtained from tubercular cows (healthy as to the udder) at the slaughter-house; and it was found that in one case dilution 1 in 40, in another 1 in 50, in a third 1 in 100, was necessary to extinguish the virulence.

This does not, however, prove that prolonged use even of "diluted" virulent milk may not be dangerous, and the research confirms the view that milk may be virulent even when the bacilli present are far too few to be recognised by the microscope. (§)

2. Manufactured products of Milk.

The existence and persistence of the tubercular virus in the manufactured products of infected milk - "separated" cream, cheese, whey, butter, butter-milk - have been investigated more especially by Bang and Galtier.

Bang, in 1885 and again in 1890 (+) described experi-


ments on various of these products made from the mixed secre-
tions from the healthy and diseased quarters of the ud-
ders of cows affected with tubercular mammitis. He found
with reference to (1) Cream obtained by the centrifugal
separator: most of the bacilli are left in the residue,
but if they were very numerous the cream would contain
enough to produce tubercular lesions by inoculation.

(2) Cream obtained by standing from 48 to 48 hours,
both sweet and sour, contained an active virus.

(3) Butter-milk was also infectious.

(4) Butter made from cream, both sweet and sour,
contained a virus which proved active on inoculation.

Some of the butter was given on bread to two rabbits,
one of which ate greedily of it, while the other took but
little: both were killed at the end of three months; the
former showed only a few traces of tubercle, the latter not
a trace. So that butter, virulent on inoculation, proved
really harmless in the digestive tract.

Heim (+) using milk contaminated artificially with
small quantities (a few drops in 50 cc.) of pure cultures
endeavoured to determine, by the intraperitoneal method in
guinea-pigs, the duration of virulence and influence of
putrefaction. (§) He tabulates his results:

<table>
<thead>
<tr>
<th>Time of Injection into animal</th>
<th>Tuberculosis in Milk</th>
<th>Tuberculosis in Butter</th>
<th>Tuberculosis in Curds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately after Mixture.</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
</tr>
<tr>
<td>After 2 days</td>
<td>Active</td>
<td>Active</td>
<td>Active</td>
</tr>
<tr>
<td>&quot; 10 &quot;</td>
<td>Active</td>
<td>Active</td>
<td>Active (Animal died next day)</td>
</tr>
<tr>
<td>&quot; 14 &quot;</td>
<td>Sterile</td>
<td>Active</td>
<td>Sterile</td>
</tr>
<tr>
<td>&quot; 4 weeks</td>
<td>Sterile</td>
<td>Active</td>
<td>Sterile</td>
</tr>
</tbody>
</table>

(§) See also Fischer: Arch. f. exp. Path. und. Pharm.
xx. 1886, p. 446
In Home made Curds Cheese.
Immediately after mixture. After 3 days
" 14 " Active Active
" 32 " Active Active
Sterile Sterile

Galtier (+) made a number of experiments on the preservation of virulence in cheese and the whey produced in the manufacture of it. He used normal milk to which was added tubercular poison obtained from phthisical cows at the slaughter houses or from the products of experimental tuberculosis in rabbits. The milk thus prepared was made into cheese in the usual way; and with it and the resulting whey, the attempts to transmit tuberculosis were made. Injections were made into guinea-pigs (intraperitoneal) and rabbits (intravenous). Fragments of cheese were rubbed down with sterile water, filtered, and the liquid used: the whey was filtered before use; thus prepared, injections were made with cheese and whey 5, 10, 15, 30, 30 etc. days old. Details of the experiments are not given, but the author states that although "all the attempts have not been followed by positive results, yet the number of instances of indubitable transmission has been sufficient to establish very clearly the preservation of the germs of tuberculosis in and, therefore, the nocuity of, the manufactured products of milk containing them." Thus a definite general tuberculosis has been obtained in the guinea-pig by cheeses aged 5, 10, and 15 days and even 2 months and 10 days in some cases, the disease appeared in only a half or a third

(+)
of the subjects: and again negative results were obtained from cheeses 2 months, or even 15 days old. Very similar results were obtained with the rabbit: thus a rabbit was killed by general tuberculosis in 9 days with whey (from milk poisoned by the juice of the spleen and lungs of a rabbit dead of tuberculosis) injected five days after expression. Salting did not seem to affect the results materially.

The broad general conclusions to be drawn from this evidence are:

1. The milk of cows suffering from tubercular disease may be, and in certain conditions is, certainly, capable of conveying the disease to animals using such milk as food.

2. The milk may contain the virus at any stage of the disease in the cow: and it certainly does so when the mamma becomes affected.

3. As the infection of the mamma is very insidious in its onset, it is advisable, as a matter of practical sanitation, that the milk of any cow suspected to be suffering from tuberculosis in any form should not be delivered for human consumption, at least in its raw state, nor should it be made into butter or cheese.

(The Preventive Measures are discussed in Chapter VI.)
CHAPTER III.

EXPERIMENTAL EVIDENCE AS TO FLESH

Including in the term "meat" not only the flesh of animals, but all the viscera generally or occasionally used for food, we now come to a discussion of the most difficult and debatable part, as well as the most important economically, of the subject. There is a pretty general consensus of opinion that the ingestion of matter actually tubercular (such as tubercular glands or lung tissue, in a raw condition) may and does produce tubercular disease in animals subject to it: but a great battle rages around the question "Is there any danger in the use of the apparently healthy parts of animals presenting only a few "localised" tubercular lesions and otherwise in good condition? This really involves the more general question: "Is localised tuberculosis possible? and if so, what constitutes localised as distinct from general tuberculosis? or, practically, how is an inspector of slaughter-houses, say, to know when he has to deal with a carcase affected with localised disease which he may pass, or with a general disease which he must condemn? Is an entire carcase to be condemned because of a single nodule in one lung? A very definite scientific proof of danger arising from such a carcase must be given to justify the sacrifice of so much food-material, and the enormous rusk of loss which would thereby be incurred by breeders and butchers.

1. It will not be necessary to enter at any great length into the researches that have for their object the proof that tubercular material, such as diseased viscera
or membranes, is capable of transmitting the disease to animals consuming it as food.

The classical researches of Chauveau have never been effectually contested. In 1868 (+) four healthy calves were purchased and placed in similar and sanitary surroundings. On September 19th three of the calves (Nos. 1, 2 and 3) received thirty grammes of tuberculous matter from the lungs of an old phthisical cow: the matter was pounded in a mortar, dissolved in water, and administered at intervals from a bottle. No. 4 calf was kept for comparison. At the commencement of October No. 1 had lost condition, and its respirations had become quickened: No. 2 and No. 3 were in excellent health. On October 5th and 7th, Nos. 1 and 3 received a certain quantity of tuberculous matter from lungs in a less advanced stage than the previous feeding material.

Not to enter into all details of the course of the disease, we find that after October 9th, No. 1 became rapidly much worse: No. 2 began to develop symptoms, one of the most remarkable of which was in the glands of the neck near the larynx. No. 3 resisted longest, and showed no appreciable change of health until October 25th, when the symptoms of tuberculous infection then developed with the greatest rapidity, and in eight days it was "irrecognisable." No. 4 remained healthy throughout, although at first the most puny of the four.

On November 10th, 52 days from commencement of the experiment, Nos. 2 and 3 were killed, and immediately sub-

mitted to autopsy, which in each case revealed most extensive and profound general tuberculosis, (the lesions of which are described in detail). No. 1 was kept for study of subsequent alterations at a more advanced period of infection.

Chauveau stated as his conclusions: -

1. There can be no doubt as to the virulence or contagiousness of tuberculosis.

2. The digestive tract (in man and in bovidae) is a possible channel for the entrance of infection; and possibly acts as such more often than the lungs.

3. If human and bovine tubercle are similar, there is danger in feeding on meat from tubercular animals; and measures ought to be taken to prevent the consumption of such meat.

4. Muscle per se, is probably not injurious, but only in so far as the glands enclosed in "butcher-meat" may contain the virus. Cooking will probably kill the poison, if carried far enough, which, however, it seldom is in practice: this is deduced from analogy with the taeniadae, etc.

These experiments were repeated, and considerable interest was taken in one particular repetition, now about to be detailed. (+)

In June 1869, four healthy calves, with no hereditary taint, were purchased, and placed in sanitary conditions. Nos. 1 and 2 received each 10 grammes of tuberculous material on 25th, 26th and 30th June and 6th July. Nos. 3 and 4 were kept as control-animals. In the course of 5 weeks

No. 1 had developed obvious disease of the glands (submaxillary and retropharyngeal): the others remained well. At the end of August the whole of the animals were submitted to autopsy by a Committee of the Lyons Academy, which reported as follows: (+) No. 1 showed the enlarged glands mentioned above, tubercular ulcerations in Peyer's patches, and nodules in the lungs. No. 3 (one of the control-animals) presented some disease in the bronchial and mediastinal glands, and a few foci in the lungs. No. 4 (the other control-animal) was in nearly the same condition. No. 2, a stronger animal than the others, showed only some general enlargement of lymphatic glands. These results were apparently disappointing, but it was found afterwards (and this is the interesting point) that, on one occasion, during Chauveau's absence, calves Nos. 3 and 4 had been fed from the same bucket as Nos. 1 and 2, without proper cleansing. "Either," said the Committee, "there was hereditary tuberculosis in the two control animals which were of an age at which that disease was known to be very rare, at least, near Lyons, or there had been a communication between the animals," which latter surmise was found correct; and very little doubt could remain but that the ingested materials had, in every case, determined the lesions.

Continuing his researches, Chauveau, in a letter to Professor Villemin "On the transmissibility of tuberculosis" (§) recounting his methods, and insisting on the importance of digestive ingestions in the study of transmissibility,

was able to point to eleven experiments in all. The animals were all bovines, aged less than fourteen months, at which age developed tubercle (spontaneous) is extremely rare, and all placed in the best hygienic conditions of food and housing. The tuberculous material used was derived from cows or from human lungs. The feeding was done in some cases only with a single small quantity, in others four times in a fortnight, with quantities of 50 to 100 grammes each time. The duration of the experiments was from one to three and a half months. The results were uniformly positive, no animal having escaped infection, in either the lymphatic system, the respiratory mucous membrane or the lungs, or more than one of these. Further, two control animals had remained healthy and presented no lesion on autopsy. Chauveau goes on to say that the symptoms occurring in the animals experimented upon corroborate the nature of the infection, notably the diarrhoea and the progressive general wasting and debility.

Confirmatory evidence for Chauveau's conclusions was not long wanting.

Gerlach (+) in 1869 infected a young pig by feeding it with nodules from the pleura of a phthisical cow, but failed to infect an old dog.

Harms and Günther (§), after making control experiments to determine the effect of a diet composed exclusively of sound meat on rabbits, fed: -

(1) Four rabbits with meat from a pig with advanced tuberculosis. Result: No. 1 had disease in 15 days. No 2 and No. 3 tubercular and No. 4 healthy at the end of 3 months.

(2) Four rabbits with lungs of same pig, extensively diseased. Result: All became very tubercular.

(3) Four rabbits with tubercles from phthisical cows. Result: All became tubercular, but in a less degree than in former series.

Leisering (+), (1870) fed a sheep for 3 days on affected lymphatic glands of a cow; the sheep, killed on the 85th day, showed intestinal, mesenteric and pulmonary tubercle. A second sheep received only one dose of 20 grammes, and was affected, as were numerous rabbits similarly treated.

Zürn, (§) also produced tuberculosis in pigs by feeding them with the flesh of diseased cows.

Saint Cyr, (*) fed a heifer twice within four days with 30 grammes (each time) of tuberculous material: every care was exercised in the experiment; the animal remained apparently healthy and well-nourished, but, when it was slaughtered 2½ months later, the retropharyngeal and mesenteric glands were found to be tubercular, the lungs healthy. A calf, 4 weeks old, which had had nothing but its mother's milk, was fed on five days with, in all, about 130 grammes of tuberculous matter mixed with milk: it was killed about 2 months later, and was found to have tubercular disease in


(§) Zoopath. Untersuch. 1872: quoted along with Leisering, ut supra

in the retropharyngeal and mesenteric glands and some of Peyer's patches. A control animal of the same age presented no tubercular lesions even after very minute examination.

Viseur (+) succeeded in giving the disease to cats by feeding them on tubercular meat: the result being vouched for on microscopical examination by Chauveau.

Bollinger (§) made a long series of experiments, which he arranges under four heads:—

(1) Ingestion of Tuberculous matter from Man:—

This gave negative results in 2 pigs and 2 rabbits, and doubtful infection in one pig.

(2) Ingestion of Tuberculous matter from the Ox:—

Glands, caseous matter, and the contents of the bronchi. In dogs (8) and cats (many), the results were negative: in sheep (5), rabbits (2) and pigs (4), the results were variable, but nearly always positive.

(3) Ingestion of Flesh from Tubercular Oxen:—

Positive results were obtained in 3 pigs; negative (with both uncooked and cooked meat) in rabbits.

(4) Ingestion of milk.

(See Chapter II, p. 8)

Stating his conclusions Bollinger says (inter alia) —

(1) Inoculation and ingestion of tuberculous matter from the ox produces tuberculosis in herbivores.

(2) The contents of the bronchi, when the lungs are

(+)


(§)

tubercular, produce similar effects when ingested.

(3) Ingestion of fresh tuberculous matter from the ox produces no effect on carnivores, (+) though the effect of similar material ingested by herbivores is intense.

(4) Small doses are sufficient.

Orth (§), in 1876, fed rabbits with tubercular material derived from cows and from human beings in different stages of the disease: some of the material being fresh, some boiled in water for 10 - 15 minutes. In one series of experiments, seven rabbits were fed with fresh tuberculous material, with two positive and five negative results, four control animals remaining healthy. In a second series 20 rabbits were used in four cages each containing five rabbits, which, in each cage, were treated as follows:

1. Fed with fresh tubercular material
2. "   " boiled "   " from a cow
4. "   " fresh "   " from human subject
4. "   " boiled "   " from human subject
5. Control animal.

The results were "surprising." All (four) of those fed with fresh, and three of those fed with boiled tubercular material from the cow became affected, but, very curiously, none of those fed upon human material suffered, but remained as healthy as did the control animals. In all 9 out of 15 rabbits fed with material from tuberculous cows contracted the disease.

(+)
See also Semmer, Rev. de Thierheilkunde, 1878 (negative results in 100 carnivores) p. 71; and Saur Deutsch. Zeitsch.f. Thiermed woch. Path. 1877, p.104 (Meat from tubercular animals used at Zoological Gardens, but the carnivores do not suffer)

In opposition to Chauveau and his supporters, some observers failed to obtain positive results: among these, notably, was Colin (+), who vigorously contested the conclusions of Villemin as to the specific virulence of tuberculosis, and those of Chauveau as to its transmissibility by the digestive tract, and he repeated the feeding experiments of the latter without obtaining evidence of infection. As Chauveau ($) pointed out at the time, any number of negative results go for little in the face of comparatively few positive and definite ones, nor is it a valid objection that ingestion fails in other animals if it succeeds in calves.

Chatin (*) also failed to obtain results by feeding rabbits with tubercular sputa; but overwhelming evidence has since accumulated, and it is now generally admitted that the actually diseased parts of animals affected with tuberculosis are to a high degree virulent and should never be used as food for man or (susceptible) animals.

Touissant (++) transmitted tuberculosis to pigs by feeding them with the diseased lung of a cow; and Blumberg (§§) to sheep by feeding with sputa, the mouths being previously scarified.

2. The next group of experiments to which attention is to be directed is that dealing with the virulence of blood or juices expressed from obviously diseased or ap-

(+): Rec. de Med. Vet. 1875. p. 122. (Communication to the Academie de Medecin, May 1873)
($) Ib. 1873. p. 439.
(*) Lyon Med. 1869. iii, p. 430.
(++) See Veterin: Journ: 1880. xi. p. 86.
parently healthy tissues - lung, glands or muscles - of tubercular animals. The method of injection has been largely used in these experiments, as the readiest way of determining the virulence of the fluids; the results differ in some measure from those obtained by the ingestion of the same juices.

Villemin (+) in his original researches was able to transmit tuberculosis to a rabbit by inoculating it with the blood of a person dead of phthisis.

To Touissant, (§) however, is due the foundation of our knowledge of this part of the subject. Experimenting with pigs, he produced tuberculosis by injecting an emulsion of a diseased lymphatic gland (of a pig dead of artificial tuberculosis) into the velum palati: and by the subcutaneous injection of a few drops of blood (also from a pig dead of artificial tuberculosis) - tubercular granulations being found in the pleura, lungs, liver and other organs when the animal was killed on the 61st day. Experimenting with rabbits (four) and pigs (four), he caused tubercular lesions by the injection of expressed juice from the lungs of a tubercular cow: positive results were also obtained when the juice of raw, and also of "underdone" cooked meat were employed

Semmer (*) also succeeded in infecting pigs and sheep with the blood of tubercular cows.

(+): Loc. cit.
(§): Comptes Rendus de l'Acad. de Science. xc. p. 754. (1880); xciii, p. 281 (1881); Rec. de Med. Vet. 1880 p. 318, etc.
(*): Virchow's Archiv. vol. lxxxii, p. 548, 1880.
Lange (+) infected rabbits, hens and dogs with the juice of the lung of a phthisical cow.

Baumgarten (§) transmitted tubercle to a rabbit by injecting blood from a phthisical animal into the anterior chamber of the eye.

Vallin (*) found that muscle juice from a guinea-pig in not very advanced phthisis was not virulent.

Galtier(++) in his paper to the Paris Congress, sums up his own researches and those of others between 1880 and 1888.

Numerous experiments made by injecting hypodermically into sheep and rabbits moderately large quantities of juice from the flesh of phthisical animals (which had been rejected at the Lyons Abattoirs) gave positive results in only two series out of fifteen: in a subsequent series he obtained results in a proportion of 2 to 3, by intravenous injection of expressed juice: a third series gave very similar results. Some interesting examples may be quoted.

(1) Four rabbits were inoculated.

2 with muscle-juice (from different muscles)
1 with juice from the mamma.
1 with juice from tubercular material.

All from one cow.

Tuberculosis occurred only in the last named.

(++) Combes Rendus de la Congrès de la Tuberculose, p. 76
Six guinea-pigs were inoculated:-
2 with muscle-juice,
2 with a mixture of equal parts of blood and
juice from the lung of a foetus in utero,
2 with diseased material from a mesenteric gland,
All from a cow dead of tuberculosis. The last two
alone gave evidence of tuberculosis.

In all, 14 animals received injections of muscle-juice,
and two of them alone presented evidence of infection. All
the animals furnishing the flesh used were in an advanced
stage of the disease, affecting the viscera, thoracic and
abdominal glands, but not the glands of the trunk or limbs.

More recently (1891) Galtier has made further experi¬
ments, 15, with juice from 15 seized animals, and has suc¬
cceeded only twice. He points out that larger doses (12 cc.
of juice) sometimes succeed in producing the disease,
whereas smaller ones (4 cc.) fail; and he comes to the
conclusion that the juice of the muscles of phthisical ani¬
mals may contain the virus, although in the great majority
of cases this cannot be successfully proved by inoculation.

Of other contributions to this subject at the Congress
of 1888, those of Nocard (§) and Arloing (•) especially
refer to inoculation experiments of the kind with which
we are now dealing.

Nocard refers to a series made in 1885, (+) in which the
juice of meat from eleven phthisical cows was injected into

(+) Lyon Med; lxvi. p. 325. 1891.
(§) Comptes Rendus de la Congrèes de la Tuberculose, 1888
p. 49, et seq.
(•) Ib. p. 59 et seq.
p. 49
the peritoneal cavity of guinea-pigs without any positive results: he also relates a second series in which, with the strictest antiseptic precautions guinea-pigs were inoculated with muscle-juice from 10 cows, all in advanced phthisis; most of the guinea-pigs were killed in from two to three months, and in only one case was any tuberculosis developed.

Arloing refers to some experiments communicated by Chauveau and himself in 1885. In these (1) 10 guinea-pigs were inoculated with juice from tubercles taken from phthisical oxen, and all the ten became infected, while of 20 guinea-pigs inoculated with muscle juice from the same animals, only two became tuberculous: (2) in a second series six guinea-pigs were inoculated with uniformly negative results.

Kastner (+) published a careful research in the following year (1889). With every precaution against sepsis and accidental contamination, he removed apparently healthy muscle from different parts of phthisical cattle, and expressing the juice, injected 1 cc. into the peritoneal cavity of a guinea-pig. 16 guinea-pigs were thus treated with juice from 12 cows (or oxen) and the result was uniformly negative.

On the other hand Steinheil ($) (like Kastner, a pupil of Bollinger) succeeded in causing fatal tuberculosis in 15 out of 18 guinea-pigs by inoculating them with juice expressed from the psoas muscles of nine human beings dead

of phthisis; no bacilli could be observed in the juice.

Woodhead (+) was able to produce tuberculosis (in two rabbits) by intraperitoneal injection of juice expressed from the intercostal muscles of a tuberculous cow, from which all tuberculous pleura had been very carefully stripped; but the juice taken from the thigh muscles of the same animal was innocuous to two other rabbits. (§)

Bang (§) reported to the Congress of Hygiene last year a series of experiments made with defibrinated blood of twenty phthisical cows, which he injected intraperitoneally into 38 rabbits and 2 guinea-pigs, with the result that in only two of the cows was the blood infectious and then in only one of the two animals used.

This writer, summing up the results of some of the observers already quoted, finds that of 73 phthisical cows, only 10 gave a virulent muscle juice. The number of bacilli (or their spores) must be very small, and even admitting the "constant supply" view put forward by Chauveau and Arloing to be true, the amount of the supply in "localised cases" will be minimal; and infection is probably less easy by means of the digestive tract than by injection.

The natural duration of virulence in the blood or juice of muscles was investigated by Nocard (++), who found that it lasted only a few hours in the blood, but that muscle juice was virulent up to the sixth day.

Galtier, (§§) in dealing with the problem as to how

(+) "Bacteria", 1891. p. 222.
(§) Galtier notes this "local variation" Lyon. Med. lxvi. p. 325
(*) Nordisk. Med. Arkiv. xxiii, No. 25
(++ Comptes Rendus de la Congres de la Tuberculose, 1888.
far there was any danger in the use of the blood of tuberculous animals for clarifying wine, found that the duration was short in the presence of alcohol even in small percentages.

3. We next turn to the effects of the *injection* of the apparently healthy flesh of animals exhibiting tubercular lesions more or less localised. This part of the subject is perhaps of less scientific interest, but is of greater practical import than that dealt with in the section immediately preceding: for, after all, we eat our meat (usually cooking or otherwise preparing it) and do not take it by hypodermic injection: in other words, the action of the digestive juices on the micro-organism cannot be left altogether out of account.

From the scientific point of view, it is necessary to use inoculation as a test: it is vain to say that muscle-juice contains few bacilli or none: it may, and as inoculation experiments prove beyond a doubt, often does contain an active virus, — the spores of the bacilli, — which free spores we have at present no means of detecting by the microscope.

But from a practical aspect, we cannot afford to neglect the action of the digestive juices, and experiments have been made with a view to determine what action the gastric juice in particular has upon the vitality of the virus.

Nornani (+) took up this question in the course of a long research on the life conditions of the tubercle ba-

(+ \text{ Annali Universali. 1884. Vol. 269. p. 157.}
cillus. He used artificial digestion, with a carefully prepared gastric juice from the pig - as an omnivore, and therefore probably akin to man - and digested sputum rich in tubercle bacilli: a piece of coagulated albumen was used as a test of the progress of digestion. In four experiments, he found bacilli at the end of four hours, although the rest of the sputum was digested to amorphous granules, whilst at the end of 24 hours, the bacilli were not to be traced, nor did the products of digestion produce any ill effects on a guinea-pig. The conclusions arrived at by Sormani are:

(a) Complete physiological digestion in the gastric juice of an omnivore, destroys not only the vitality but even the form of the bacillus.

(b) This destruction is not a phenomenon of early digestion; in other words, these micro-organisms are, from their structure, not readily attacked.

(c) Too short an exposure to the digestive juice, or a juice deficient either in digestive ferment or acid, does not kill the bacilli.

It is possible that the spores which escape from the stomach, vegetate in the alkaline intestinal juices: they may either cause lesions in the intestine, or may find their way into the mesenteric glands, producing disease there or not, and thence spreading to the lungs.

Wesener (+) submitted sputa to various conditions, including the action of digestive juices, and introduced the resulting materials directly into the stomach or intestine.

(+) Loc cit.
of rabbits: he thinks that the spores survive the destruction of the bacilli: direct injection into the intestine rapidly produces tuberculosis therein: probably when the spores are very few in number the glands can get rid of them before they have time to multiply.

Straus and Wärtz (+) showed that the tubercle bacillus (from cultures) resisted the action of the gastric juice of the dog at 38° C. for 18 hours, but their virulence (as tested by inoculation on rabbits and guinea-pigs) was destroyed at the end of twenty four hours.

Nocard (§) believes that, in tuberculosis as in other microparasitic diseases, the spores of the organism are able to resist gastric digestion.

Some of the earlier experiments with the flesh of tubercular animals have been already alluded to. (Harms and Gänther, Zärn, Gerlach and Viseur).

From his observations Gerlach (*) was led to believe that though at first the disease may be localised, the virus eventually spreads through the body and becomes more or less generalised; and according to him, any of the following conditions was evidence of unfitness for food: namely, disease of the afferent lymphatics of the organs affected; caseous centres, especially in the lungs; secondary extension of the tubercles; and evident emaciation.

Johne's (++) opinion is that in order to be really injurious, the tuberculosis of the animal must be generalised.

(+) Comptes Rendus de la Congrès de la Tuberculose 1888, p. 330
and, except in such condition, there is no need to condemn the carcase, provided the affected viscera are seized.

The same authority states (+) that of 46 experiments in which animals were fed on raw flesh of tuberculous cows, the positive results amounted to 13.1 per cent, the negative to 86.9. Gerlach had 8 positive results in 35 animals, nearly 23 per cent. The positive results of the ingestion of morbid material is given by Johne as 61.5% in 117 experiments.

Nocard (§) reported in 1888 some experiments in which cats were used.

(1) Four cats fed with raw minced meat from a cow; all remained well, and showed no trace of tuberculosis at the end of five months. A cat, fed with pleura from the same cow died in a month with general tuberculosis.

(2) Three cats were fed with the milk of another phthisical cow, and lived unaffected for five months.

(3) Four cats fed each on four occasions at intervals of 5, 18 and 15 days, showed no sign of tuberculosis at the end of five months. Among the meat used in this experiment was some, the juice of which gave a positive result when injected into a guinea-pig. (antea p. 40)

Baillet (*) has never succeeded in conveying tuberculosis by meat properly so-called, ingested in the ordinary way, and derived from animals with localised tubercle only, and with the external appearances of health.

(+)
Loc cit.

(§) Comptes Rendus de la Congrèes de la Tuberculose, 1888.

(*) Comptes Rendus de la Congrèes de la Tuberculose, 1888.

No details are given of the experiments.
Galtier (+) fed seven animals (a puppy, kitten, two chickens and three dogs) on raw meat from tuberculous cows, at intervals frequently for nearly six months, and not one became affected: four guinea-pigs similarly treated, remained healthy.

Arloing (§), on the other hand, believes that infection by ingestion is at least as frequent as by inoculation: he cites 11.8 as the percentage of positive results in the former class; and 9.4 for the latter.

As a general conclusion one may state that with reference to the use of the apparently healthy flesh of animals found to have suffered from tuberculosis (such flesh being in fair condition, and in other respects fulfilling satisfactorily the requirements of the butcher and consumer).

(1) Such meat may, in certain cases (*) be dangerously infectious, but this is quite exceptional.

(2) When the meat is infectious, it is always to a very feeble extent.

Or, as Arloing has it: -

(1) Is there any danger? Yes.

(2) Is that danger great? No.

(+), Lyon Med. lxvi. 1891.

January and February.

(*) It must not be forgotten that, in actual practice, joints are sold containing glands, which, although perhaps normal to the naked eye, may contain active tubercle virus: these, if deeply enough situated to escape thorough cooking, are certainly capable of conveying the disease.

Baillet says he has never met with such a case. Woodhead and Mc Padyean communicated to the Congress of Hygiene, (London, 1891) a case in which tubercular disease was found in the connective tissue of the muscles, but not in the lungs or other viscera.
CHAPTER IV.

CLINICAL EVIDENCE.

Heron (+) has collected a series of cases in which there is reasonable probability that tubercular disease has been communicated to the human subject by the ingestion of milk or meat derived from tubercular animals. These, with some further similar ones, and some in which animals have been the subjects of similar accidental experiments, are here briefly described.

1. (§) A child nursed for four weeks by a phthisical wet-nurse; the glands of the neck enlarged and contained tubercle bacilli: the lungs remained healthy.

2. (*) An infant was fed with unboiled milk from a cow: the child was healthy and its heredity good, but it sickened and died in 4 months. Post-mortem examination revealed extensive tubercular disease of the mesenteric glands, the intestine and other organs being healthy. The cow was slaughtered, and was found in a state of advanced tuberculosis; Koch's bacilli were found in milk pressed from the udder.

3. (+++) C. is a healthy village situated 2,000 feet above the sea level. A young man previously healthy caught phthisis while a prisoner of war: returning


(*) Heron: Case 11: Demme; Schmidt's Jahresbuch 1888 V. CCXVII p. 144.

to C. he married a healthy young girl and died of phthisis within a year: the girl took the disease, and their child also rapidly developed the affection. Another young girl in the village shewed symptoms of phthisis: she had not been in the habit of visiting the first named, but it was shewn that she had eaten the underdone flesh of eleven fowls, reared at the first-named's house, and which had swallowed sputum from the patients there: one of these fowls was shewn by necropsy to be tubercular.

4. (+) A case of phthisis in a person with no hereditary history, ascribed by Meyerhöfer to the prolonged use of the milk of a tubercular cow.

5. ($) Four children suffered from abdominal tuberculous after drinking the milk of a tubercular cow.

6. (*) A case of probable infection by milk in a child.

7. (+++) A child was fed with (warm) milk of one cow: the child died of intestinal and mesenteric tubercle. The cow was found to have wide-spread disease in its lungs and pleura.

8. (§§) A boy of five years of age, healthy, and with no hereditary taint, drank the milk of a tubercular cow for two or three years, and became tubercular.

(*) Heron, Case 64: Uffelmann: Arch. f. Kinderheilkunde 1880, I., p.414.
(+++) Heron, Case 67: Demme: 17th Rep. Jenner Children's Hospital, Berne 1879.
9. (++) A (not very clear) case in which five members of a family previously healthy, and without any tubercular hereditary taint, became affected soon after 3 or 4 cows (in a herd of 20) began to shew signs of phthisis.

10. ($) A strong and vigorous family of two girls and two boys lived on an island on the coast of Scotland: the cattle on the island became tuberculous: the two girls when young, were fed largely on milk, and died of tuberculosis: the two brothers "who were more fond of whiskey than milk" remained healthy.

11. (*) A man was in the habit of buying all the "wasters" he came across: the milk was used by his family for food purposes: many members of it were attacked with phthisis and died.

12. (++) A girl contracted phthisis and died. It found that of three cows which supplied the milk which was her principal diet, two were tubercular.

13. (§§) A cow died of rapid general tuberculosis: when in apparently good health its milk had been used for the food of a child: the child, previously healthy, died at 2½ years of age of miliary tuberculosis of the brain. Other older children of the same family healthy.

14. (***) Two pigs of same litter were fed with milk

(•): Göx. ib, p.162.
(++): Ib.
(**): Bromley: Veter: Journal V. xi p.93, 1880.
from a cow, which afterwards became ill, died, and was found to have tubercular disease: the pigs presented tubercular lesions in the lungs and pleura. The sow (mother of the pigs) when subsequently slaughtered was perfectly healthy.

15. (+) A child five years old was allowed to consume for a long time the milk of a tubercular cow, and died of tuberculosis of lungs and mesenteric glands: there was no hereditary disease.

16. ($) Epstein describes nine cases of abdominal tubercle in infants from 10 weeks to 10 months old: two were the offspring of healthy mothers, but suckled by phthisical wet-nurses: he attributes the comparatively greater frequency of abdominal tubercle over pulmonary tubercle to feeding with milk of diseased cows.

17. (*) Walley attributes the death from abdominal tubercle of one of his own children to the ingestion of tubercular milk.

18. (++) Fleming believes that one of his own children died from a similar cause, the disease becoming manifest first in the cervical glands.

19. ($$) A gentleman imported some Irish hens which

(+). Case described by Stang of Amborach: I have not found the original description, but the case has gone the round of the literature: e.g. Bollinger: Deutsch. Archiv. f. Thier Med and vgl Path. vi p.103 1880: Dolan, Practitioner 1881, i., 356: Lydtin's "Report." 1885. p. 31.
($) Prager Vierteljahresschrift V.1 142 p.103.
(++) Personally communicated to the writer.
which communicated tubercular disease to his other poultry, which was attended by his daughter; the girl died of phthisis, though there was no hereditary taint.

20. (+) Woodhead describes a case in which the milk of three cows with tubercular mammitis was sent into a large establishment and there only: the death rate from phthisis in that establishment was for one year 40 per cent, and for another 30 per cent of all deaths.

Pigs were also fed (in the same establishment) with the milk: and a large number of them became tubercular; other pigs in similar conditions but not fed on this particular milk, remained healthy, and yet others in the same stall as the first had been, remained healthy when the tubercular milk was stopped.

21. (§) Two cases very like each other of apparent infection by mother's milk are described by Peel Ritchie; in each of these cases a child was suckled by its mother, who developed first some nodular enlargement of the breast and afterwards phthisis of which she died in a few months, the child pre-deceasing the mother, dying from tubercular meningitis: the father in each case, was healthy.

22. (*) Ollivier described a series of cases occurring in a school; one of which, that of a girl aged 20, who died of tubercular meningitis four years after leaving the school, came under his own observation: thirteen other cases occurred within a few years, of which six

(+) Edin: Med: Journal V. 33, p.1113.
were dead: and the outbreak was attributed to the milk of a tubercular cow supplying the school. Subsequently (+) it was found that the tuberculous cow in question had been purchased after the girl in question had left the school; that its milk was only exceptionally used by the scholars, and was always boiled. The unusual occurrence of thirteen cases within a few years is yet unexplained.

23. **Ernst (§)** cites a case in which three children of one family died of tubercular disease derived from a diseased cow, the use of the milk being continued in spite of the definite warnings of a Veterinary Surgeon: there was no heredity.

24. **Niven (*)** refers to a case of infection of pigs by milk of tuberculous cows withdrawn from the markets, necessitating slaughter of the whole stock.

On the contrary, **Goring (++)** cites the opinions of a number of veterinary surgeons in Bavaria, tending to show that tubercular meat and milk may be consumed with impunity: e.g. Brell (of Mindeheim) knew of a pig fed on tubercular meat remain healthy, and also a family which for many years fed on tubercular meat and sausages, yet enjoyed good health.

**Gallavardin (§§)** records a case in which he and his family and some neighbours, in all eighteen persons, used milk from a cow in good condition which was sent to be

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(*) : Lancet 1889 II, 183.
(++) : Deutsch Arch. f. Thiermed u. Vgl Path. 1878 p.289.
(§§) : Lyon Med: 1891. l vol. lxxvi, p. 333
slaughtered, and, to his surprise, was found to have extensive tubercle in the lungs, pleura, liver and peritoneum. (No mention is made of the condition of the udder); a condition which must have been of at least a year's standing: none of the persons were in any way affected. The milk was also given as specially good, to a child with commencing phthisis: and she recovered completely.

Cameron (+) has seen infection in pigs under peculiarly favourable conditions.

It is unnecessary to discuss this evidence at any great length; the negative cases go for little. As to the others, though in no one case can it be absolutely declared and proved that the milk (or flesh) was the source of infection, yet the circumstances of each case are such as to render it probable that it is so: and, as has already been pointed out, cases such as these are the only ones approaching a direct proof of transmission of tubercular disease from animals to man through the medium of the digestive tract. (§)

What may be considered clinical evidence in a more extended sense has been provided by Lydtin (*) in the form

(+) Veter. Journal. 1892. (March and April)
(§) Much more numerous, and more easily established, are instances of inoculation through wounds, or infection by cohabitation: see e.g. Heron op. cit. passim.
of a Table, issued in 1881, "shewing the deaths caused by tuberculosis among the people and also among the cattle, in the different administrative districts of the Grand Duchy of Baden in 1881". Excepting in five districts in which a great deal of inferior meat is sold (as sausages or otherwise) there is a close parallelism between the two curves: the figures given are for only one year; doubtless over a number of years, more exact indications may be obtained.

Brush (+) brought forward somewhat analogous evidence in a series of quotations from the writings of travellers which tend to shew the "coincident geographical distribution of tuberculosis and dairy cattle"; e.g. among the Esquimaux and the inhabitants of the Russian Steppes, who have no cattle, tuberculosis is apparently unknown.

CHAPTER V.
CRITICAL REMARKS ON THE EVIDENCE IN GENERAL

Several considerations are suggested by the evidence set forth in the previous sections.

Dealing first with the methods of experimentation, we have, as has already been remarked, two different classes of experiments, (1) those in which the suspected materials are introduced by injection, into the subcutaneous tissue, the peritoneal cavity, or a vein, and (2) those in which the materials are introduced by ingestion into the digestive tract in the ordinary way.

Certain difficulties are common to both classes; and these are, in part, stated in Virchow's paper already alluded to. (+) A great part of this paper is occupied with evidence tending to disprove, on pathological grounds, the identity of human and bovine tuberculosis; since 1880, however, evidence has been brought which places that identity beyond all reasonable doubt, and this initial difficulty disappears.

Another practical difficulty is not quite so easily disposed of: before we can make use of statistics of results of experiments, we must have some notion of the frequency with which spontaneous tuberculosis occurs in the animals experimented upon. Absolute statistics on this point are wanting: it is even very difficult to obtain definite information with reference to the larger and more valuable domestic animals, and it is quite impossible to

obtain it in the case of rabbits and guinea-pigs, and such small creatures usually the subject of experiment. But as a result of a very large number of post-mortem examinations of the thousands of rabbits and guinea-pigs, cats and dogs, used for experimental purposes of various kinds, it is known that spontaneous tuberculosis occurs in them very rarely, and that, while this is the case, tubercular lesions very rapidly and very typically develop in rabbits and, more especially, in guinea-pigs, when evoked by inoculation.

Again, can we be sure that the particular animal used was not already suffering from the disease before inoculation? It is admitted that tuberculosis may exist in an early and "localised" state, while the general condition of the animal remains good. But among the "experimental" animals this must be very rarely the case. (+)

It is also stated by Virchow that in some of his feeding experiments the lesions found did not correspond in age with the duration of the experiment: that, for instance, he found old and even calcified tubercles in pigs which had been fed on tuberculous material for from four to six weeks. This may have been in one of those cases in which previous disease existed; and such a source of fallacy is eliminated by a sufficiently extended series of experiments.

The next difficulty is one which applies very generally to the results of experimental physiology and pathology, namely, "species differences": and there are very

(+ And probably, according to Nocard, Arloing and others, in Koch's tuberculin we have a reliable test in any doubtful case.
wide differences in the readiness with which the various species are affected with tuberculosis. How far we are justified in arguing from guinea-pigs to man can only be determined by careful observation, in this as in all such questions. (+)

The possibilities of accidental contamination and contagion during the long time required for these experiments must be considered: this, as we have seen, has occurred especially in the earlier experiments, even of Chauveau himself. Now that the nature of the active agent in the contagion is known, precautions can be more thorough, and recent observers have paid the closest attention to the hygienic surroundings of the experimental animals, as well as to due sterilisation of instruments, feeding-dishes, and the like, thereby reducing the risk of such contamination to a minimum. By similar precautions, inoculations of septic material are avoided.

Turning now to some criticism of the results of experiments, it must be admitted, as pointed out by Duclaux, (§) in a very able critical review of Kastner's paper, that the whole question of infection by the digestive tract with regard more especially to the apparently healthy flesh of tubercular animals is in a most unsatisfactory condition, that irreconcilably contradictory results have been obtained.

(+)

See, for example, the contradictory results of Kastner and Steinheil, (antea p. 40) and certain experiments of Gratia and Liénaux (cited by Galtier: Traite des Maladies Contagieuses, Vol. ii, p. 476) who obtained tuberculosis by inoculating guinea-pigs with muscle juice of two men dead of phthisis, but failed with juice from the flesh of tubercular animals.

by competent observers, and that the factors involved are more complex than would appear at first sight.

In the first place negative results of feeding experiments cannot be held to be of much value, for not only has the presence or absence of the virus in the food to be considered, but also the state of the alimentary canal must be taken into account, and we can never say that in any given case of negative result the latter factor was not the cause of the failure of infection. So, too, when it is argued of clinical experience, that infection from meat or milk is rarely proved; we may reply that it is impossible to show that any given case was not due to this particular source of infection. The experiments of Sormani, Wesener and Straus tend to show that the vigour and completeness, or the reverse, of gastric digestion have an important influence upon the vitality of the virus, and upon the risks of infection: Wesener's results particularly point to this, for he has shown that of his most susceptible animals (pigs) only one half were affected, rabbits only rarely and dogs not at all; thus showing that species-differences are not capable of explaining wholly the varying results; and it is at least reasonable to suggest that the condition of the digestive tract at the time of receiving the poison may be one, if not the only, differentiating factor.

In this connection, Martin (+) has pointed out as an interesting analogy, that 99 per cent of persons absorbing curara present no symptoms of intoxication; yet there can

(+)

Rev. de Med. 1884, p. 150.
be no doubt of the effects of that intoxicant in cases where it produces them.
CHAPTER VI.
PREVENTIVE MEASURES

The means of preventing the transmission or risk of transmission of tuberculosis to man through infection in his food, divide into two classes: first, what may be termed the measures of Private Hygiene; and secondly those of Public Hygiene. The former class includes a consideration of the effects produced on the virus by the various methods of preparing food - cooking, salting, etc. The latter deals with the legislative and administrative remedies, which have been proposed to mitigate the evil.
I. PRIVATE HYGIENE.

THE EFFECTS OF HEAT.

A large number of experiments have been made with a view to determine the minimum Temperature and duration of exposure thereto which will suffice to render absolutely innocuous any tubercle bacilli, or, more strictly, their spores, which are known or are suspected to be present in any given sample of milk or meat.

1. With regard to milk, Klebs (+) as has already been stated, found that boiling was not sufficient to kill the virus, but he gives no details of his temperatures, nor of the time of exposure. The experiments of Bollinger (§) and of May (⋆) with boiled milk have already been alluded to; they found such milk to be innocuous, both on inoculation and on ingestion.

Bang has made many researches to determine more exactly the Temperature required for destruction of the microbe.

At the 1888 Congress (++) he reported a series of experiments on rabbits: they were fed with milk from tubercular cows:

(1) Of 6 fed with raw milk all were infected, 4 very highly.

(2) " 2 " " milk warmed to 60° C., 1 was infected slightly.

(3) " 2 " " " " 65° C., 1 was infected slightly.

(+) Supra p. 8
(§) Supra p. 9
(⋆) Supra p. 11
(++) Q.R. de la Cong. p. 69
(4) Of 6 fed with milk warmed to 70° C., none were infected.

(5) " 2 " " " " 75° C., " "

A more elaborate set of researches was published in 1890 (+). These may be tabulated as follows:

INOCULATION EXPERIMENTS:

1st Series. A sample of "separated" milk, full of bacilli:
warmed for five minutes (in all cases in a waterbath)

50° C. )
55° C. ) Two rabbits each; all died in from \( \frac{7}{2} \) to 10 weeks: of general tuberculosis.
60° C. )
65° C. )
70° C. ) Killed in \( \frac{7}{2} \) weeks: no trace of Tubercle.

2nd Series. The mixed secretion of two cows affected with tubercular mammitis.

Not warmed: 1 rabbit: became very tubercular.

Warmed to 62°, 1 rabbit: a few tubercles in the organs.

" " 67°, 2 rabbits:) a few tubercle nodules.

" " 70°, 1 rabbit: }

It appears that above \( 60^\circ \) the virulence is diminished: a very short exposure to \( 70^\circ \) is not enough to kill the tubercle bacillus (or its spores).

3rd Series. The mixed secretion from the sound and diseased quarters of a tubercular udder, that from the latter rich in bacilli.

<table>
<thead>
<tr>
<th>No. of rabbits</th>
<th>Temp. C.</th>
<th>Time of exposure minutes</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>not warmed</td>
<td>-</td>
<td>All died of Tuberculosis in 1 1/2 to 2 months.</td>
</tr>
<tr>
<td>(2)</td>
<td>60°</td>
<td>5</td>
<td>All died of Tuberculosis in 1 1/2 to 2 months</td>
</tr>
<tr>
<td>(3)</td>
<td>60°</td>
<td>15</td>
<td>3 killed in 3-4 1/2 months healthy: 1 died after 9 months of Miliary Tubercle. Killed at 3 months: 2 healthy, 2 tubercular.</td>
</tr>
<tr>
<td>(4)</td>
<td>65°</td>
<td>5</td>
<td>2 healthy, 2 tubercular.</td>
</tr>
<tr>
<td>(5)</td>
<td>65°</td>
<td>15</td>
<td>1 died at 2 1/2 months of Tubercular Peritonitis. 3 killed at 3 months, in good condition but tubercular.</td>
</tr>
<tr>
<td>(6)</td>
<td>70°</td>
<td>5</td>
<td>Killed at 3 months: 1 healthy and 3 very tubercular.</td>
</tr>
<tr>
<td>(7)</td>
<td>70°</td>
<td>10</td>
<td>Killed at 3 months: 2 healthy and 2 very tubercular.</td>
</tr>
<tr>
<td>(8)</td>
<td>72°</td>
<td>5</td>
<td>1 died in 5 days of septic peritonitis. 3 killed at 3 months very tubercular.</td>
</tr>
<tr>
<td>(9)</td>
<td>75°</td>
<td>5</td>
<td>All tubercular at 2 1/2 to 3 months.</td>
</tr>
<tr>
<td>(10)</td>
<td>80°</td>
<td>5</td>
<td>1 died from peritonitis; 3 found tubercular at 3 months.</td>
</tr>
</tbody>
</table>

4th Series. Milk warmed from 80° to 85° all remained healthy.

5th Series. Milk from advanced tubercular mamritis.

Experiments made with raw milk and with speci-
mens heated for five minutes to 70°, 75°, 80°, 85° and 100°. Four Rabbits inoculated with milk heated to 85° and 100° remained healthy for 2½ months: the others, examined in from 1 to 2½ months, were found tubercular.

**6th Series.** Raw specimen killed the animals.

Specimens heated to 80°, 85°, and 100° for five minutes, produced no effects after four months.

To these some interesting *feeding* experiments were added, resulting as follows:

(1) Raw milk: 6 rabbits: all developed typical tuberculosis.

Warmed to 60° to 65° 2 rabbits: one showed traces of tubercle.

" 70° 6 " one died by accident
5 remained healthy at the end of 4 months.

" 75° 2 " Ditto.

(2) Raw milk: 4 pigs: all died of tuberculosis.

Warmed to 65° 2 pigs: suffered from less advanced disease.

" 70° 2 " both remained healthy.

The general results are:

Heating to 80° C. is not sufficient to kill the bacillus or its spores.

Heating to 85° C. seems to be sufficient to do so.

Heating to 100° C. is certain death to these microbes.

Galtier, Chauveau and Arloing, and others have made similar researches, but the whole of these preventive mea-
sures with regard to milk resolve themselves into this - "Boil all milk".

Not only in reference to tuberculosis but in reference to any other infectious disease, the rule to boil all milk is an excellent one; and no doubt it is the duty of medical practitioners to preach this doctrine to their patients. But the writer’s experience, (which no doubt is that of others) is that people will not boil all their milk, even under the fear of an active epidemic; they do not like the flavour of boiled milk, and, especially among the poorer classes where the danger is greatest, they will not take the trouble, particularly as the contingency for which the measure is recommended is not within their knowledge nor their medical traditions, and is looked upon as very remote.

2. With regard to the influence of heat upon the vitality of the virus in meat, or muscle juice,

**Touissant (†)** shewed that the juice from the centre of a "joint" from a tuberculous animal, retains its virulence if the cooking be imperfect, and the meat be "underdone": he gives a warning against the use of such undercooked meat, which, however, many persons prefer; he also shewed that juice of tubercular lung retained its virulence at 55° to 58° C.

**Galtier ($)** shewed (in 1879) that a temperature of

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(†) C.R. XCI, 1881
($) C.R. de la Cong. de la Tub. 1888.
70° C. continued for a certain time was sufficient to sterilize fresh tubercular virus; he has failed to transmit tuberculosis to rabbits and guineapigs by intravenous injection of milk and muscle juice which had been heated to boiling, while the same material heated to any less degree continued virulent; and it is to be noted that the centre parts of meat cooked on the grill do not attain to boiling temperature. Galtier has also found that tuberculous material heated in sealed tubes, remained virulent to guineapigs after exposure to 60° C. for 20 minutes, and to 71° for 10 minutes.

Chauveau and Arloing (+) found that at temperature of 70° maintained for half an hour was not always a guarantee of safety, but that a temperature of 100° continued for the same time was certain to sterilize the virus.

Cooking is, no doubt, an admirable protection against tubercular infection, provided that, in the process, a sufficiently high temperature be attained in all parts of the meat used. This, we know, is by no means always the case. And it has been suggested that, if we seize every carcase tainted with tuberculosis in however slight a degree, the "unaffected" parts should be sold to hospitals and cook-shops, where the cooking of animal food is believed to be better attended to than in the homes of the poor (§) to whom such meat is at present

(+1) Cited by Galtier: loc. cit.
chiefly sold.

The effects of freezing, and of exposure to alternations of temperature have been investigated by Galtier (+) who found that the bacillus remained active in tissues exposed to temperatures varying from (e.g.) \(-7^\circ\) to \(+8^\circ\) during ten days and nights, in the winter.

It is inferred that freezing, now much employed to preserve meat is not capable of destroying the virus of tuberculosis if it exist in the meat.

The effect of salting and smoking.

Galtier (§) made in 1887-88 a series of experiments to determine the effect of salting upon the vitality of the tubercle virus.

(1) Guineapigs inoculated with the product of tubercular organs submitted to the action of kitchen-salt in the proportion of 6 grammes of salt to 16 of material for forty-eight hours, contracted the disease.

(2) Three pieces of a very tuberculous testicle and three from the lungs of the same animal (weighing in all 130 grammes) were salted with 50 grammes of salt, and two pieces of the same testicle and two of the lung (weighing in all about 50 grammes) were salted with 32 grains of salt: all of the pieces were approximately the same weight; and the virulence of the testicle had been proved

(+)
Loc. cit.

(§)
Loc. cit.
by inoculation of two rabbits, and afterwards of a guinea-pig (from the rabbits). The temperature of the laboratory varied from 5° to 28° C.

At the end of eight days, guineapigs were inoculated with juice from all the preparations, previously washed; and all (seven) became tuberculous, as did a rabbit into which juice from one of the testicle-preparations was inoculated. Virulence, therefore persisted for eight days, in spite of the small bulk of the pieces employed. At the end of 15 days the juice of each preparation rendered guineapigs tuberculous, but did not give the disease to rabbits, and by the end of about nine weeks, no trace of virulence was left in the remaining pieces.

(3) Similar experiments with portions of liver and lymphatic gland from a tuberculous cow, shewed that, while virulence persisted on the 7th day, it had disappeared in 30 days. Forster (+) found that the bacilli in pure cultures and in the organs (lungs, pleura, liver, kidneys) of tuberculous oxen were not rendered inert by ordinary salting.

The inference is that, as even with small fragments used for experimental purposes, very prolonged salting is required to kill the virus, it is probable that the deeper parts of the larger pieces salted in actual practice are never exposed to the salt sufficiently to kill the virus; and the only advantage that can be claimed for

salting (and the same is true of smoking) is, as pointed out by Mandereau of Besancon (+) that salted meats are normally more thoroughly cooked, though others are eaten raw, whereby danger is rather increased.

The effects of smoking were tested by Forster ($) who found that an emulsion of a portion of pleurisy, studded with tubercle, taken from a smoked "joint" was virulent to rabbits and fowls: and the same was found to be the case with the salted and smoked (*) "Hamburg smoked meat" of commerce.

The tubercle bacilli are not killed by smoking, nor is the infectiveness in any way annulled; and the danger of the use of such meat if tuberculous is great, because smoked meats are not infrequently eaten without cooking (in Germany).

These researches have been confirmed by Serafini and Ungaro (++) who have shown that smoking with wood smoke, though fatal to organisms in pure vultures, does not have that effect upon the micro-organisms contained in masses of meat, and it is idle to pretend that by this means one can render harmless the flesh of animals dead of infectious diseases, especially those which are transmissible

(+): Cited Galtier, Traite des Maladies Contag. II p. 486
(*) Ten days salting, and ten days smoking.
As a general conclusion, there can be no doubt that the ordinary methods of salting and smoking (separately or combined) are not capable of rendering tuberculous meat fit for the food of man.
II. **PUBLIC HYGIENE.**

It is scarcely within the scope of this paper to discuss in detail all the preventive measures requisite for the efficient control of the spread of tuberculosis among animals, particularly cattle, and from them to man. It must suffice to enumerate the principles which ought to be observed in any legislation having that object in view.

1. There must be a distinct and clear official recognition of Tuberculosis as a Contagious Disease of Animals.

2. There must be provided some machinery for *regular periodic* inspection of all dairies and cow-byres, and for the examination of all animals supplying milk, by competent veterinary surgeons (+), who should be appointed by the Local Authorities, and be removeable only with the consent of the Local Government Board (or its equivalent in Scotland or Ireland).

3. Private slaughter-houses must be abolished, and all meat prepared at the public abattoirs, should be carefully inspected by trained and competent inspectors, who shall be experts in the matter, and whose independence and impartiality may be relied on.

4. Means should be provided of readily and effectually seizing all suspicious meat, and for preventing the use of milk from any cow suspected of tubercular mammitis.

To some extent these conditions are already in force, in some of our larger towns: in others, where perhaps the butcher interest has the upper hand, strong and successful efforts have been made to prevent the introduction of such measures.

Out of the evidence discussed in Chapter 3 of this paper, one particularly difficult practical question arises, and has been already propounded at the beginning of that section. Are we to order the total seizure of a carcase in which (to the naked eye (+) that is as the Inspector views it in the abattoir) there is only a more or less limited tubercular disease, confined (let us say) to the thoracic or abdominal viscera, and their adjacent glands?

The two views taken by those who have studied the subject may be summed up in two contrary propositions.

1. "There is evidence that the risk of propagating tuberculosis by the ingestion of apparently healthy flesh from animals in which the disease is localised is very remote: and in the absence of positive and definite proof, we are not justified in seizing such apparently sound meat and inflicting what must be a heavy loss on breeders, and butchers, on the consumer, and, if compensation is to be given, on the ratepayers."

2. "There is evidence that the apparently healthy parts of tuberculous animals are capable of conveying the disease when ingested as food: the risk is perhaps small; (+) It has been suggested that the Inspectors shall be experts in microscopy, and that doubtful carcases should be examined minutely; this is scarcely feasible."
but small though it is, it should not be permitted to exist and we must insist upon total seizure at any cost."

Strictly speaking the difference between these two views is not a question of scientific evidence at all: the facts are admitted by both sides, and the question is one of expediency, of that compromise between the ideal of scientific hygiene, and the facts of everyday existence, which is necessary in the practical application of all sanitary measures in the present day. (+)

The following summary gives the heads of the reasoning employed by the advocates of "partial" and "total" seizure respectively.

On behalf of a partial seizure, it is urged that there is a need for yet further proof that the parts purposed to be passed for human food are harmful. The experimental methods employed, other than ingestion in the ordinary way, do not give results applicable to practical questions in dealing with meat as actually slaughtered and sold. But even taking the results of inoculation and ingestion experiments into consideration, the risk of infection from the apparently healthy parts of the carcase is minimal as regards inoculation, and disappears entirely as regards ingestion. Experiments have, in the majority of cases been

(+)

"From a purely scientific point of view, the consumption of meat from tuberculous animals in which the lesions are not very advanced, is not logically permissible, seeing that the virus is communicable in infinitesimal doses. But in practice one has often to avoid straining principles to their rigorous application, to avoid a resistance which may prevent even such application as is possible at the time being."

(Bouley. Rev: de Med. 1884, p. 684.)
made with materials from advanced cases, where probably
the blood, &c., contains a much greater (though still very
small) quantity of virus, than it would contain in the
cases in which the use of the flesh is to be permitted.
Even if the virus is present in the blood, it has been
shown that the duration of its vitality is very short
(See p. 41): and that cooking, especially boiling, is suf-
ficient to destroy what feeble virus may be there. Suppos-
ing again, that the meat receives insufficient cooking,
we should do more harm by depriving the poor man of his
cheaper meat than by allowing him to eat it.

Total seizure is too arbitrary and vexatious a mea-
sure, for which no adequate scientific reason can be given
to the breeder, butcher or consumer. The breeder and
butcher will be discouraged in the raising and killing of
cattle, and the consumer will pay the penalty in an in-
crease in the cost of his already too costly meat. Such
Draconic measures only disgust those whom they are intend-
ed to benefit: public opinion is not ripe for such mea-
sures (although there has been and is still rapid advance
in sanitary knowledge and its applications): and, in this
country at least, public opinion guides the Legislature.

We even go the length of endangering the existence of
Meat Inspection altogether; being of comparatively recent
origin, it has not yet a firm nor general hold on the
public.

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Note. As to the practicability of partial seizure, it is
admittedly a difficult point: where does localised
tubercle stop, and general tuberculosis begin? The
It is further urged that the death rate from tubercular disease has not materially diminished in towns in which total seizure is in force.

For instance, at Lyons the percentage of deaths from phthisis is thus recorded (+)

views of Gerlach have been already referred to (+). Touissant believes tuberculosis to be a disease "tolius substantiae" from the outset. Johne ($) thinks that no matter how poor the condition of the animal, the flesh may be considered free from danger, and should not be rejected if there be no other cause. Zundel (*) would allow the use of all parts not obviously affected, with the recommendation of thorough cooking. Ostentag (++) has endeavoured to define exactly the meaning of the terms "local tuberculosis" and "general tuberculosis", and has formulated indications for the guidance of Inspectors, which are actually in use in the abattoir in Berlin: they are:

I. Tuberculosis is local in the extended sense of the word:
1. When the peritoneum and pleura, and the associated lymphatic glands are alone affected.
2. When one or more of the organs of one and the same body-cavity, and their serous covering are affected, (e.g. lung and pleura; intestine or uterus and peritoneum) without any of the other organs, especially the lung, appearing diseased.
3. When disease of one or more organs of the abdominal cavity is accompanied by disease of the pleura.

II. Tuberculosis is general:
1. Where disease of the pleura or peritoneum, or of both of them, exists along with miliary tubercles scattered through an organ (e.g. the lung).
2. When these two serous membranes are affected, and there exist also limited embolic foci in other organs.

In the case of miliary tuberculosis of the spleen and kidneys, the meat must always be rejected.

Lyon Med. LXVI 335.

(+) Supra p.44
($) Maint.Zeitsch.f Thiermed. Vol XI.
1876 - 17 per cent of all deaths.
1877 - 17 " " " "
1887 - 18 " " " "
1889 - 17.5 " " " "

the decree having been enforced since 1888.

By the advocates of total seizure it is urged, in reply to the other side, that although our scientific data are incomplete, the case is one in which the motto "When in doubt, abstain" does not apply, for there is unquestionably some risk, which it is our clear duty to obviate. The minimising of that risk is due to a misinterpretation of the results of experiments. Inoculation is employed as a ready test of virulence, and negative results with apparently healthy tissues, do not prove that the virus does not occur outside the macroscopic lesions: for (a) the virus may be very irregularly distributed (+) (Galtier, Woodhead); (b) the portions used in inoculation experiments are proportionately very minute; (c) many microbes must remain among the fibres &c., from which the juice is expressed; (d) the virus is poisonous in infinitesimal doses. And although it is rapidly destroyed in the blood yet a large quantity may have been present in the blood at the time of death.

Endeavouring to fix the proportional risk of infection, Arloing ($) has analysed the results of 47 research-

(+): See also Stubbe of Louvaine quoted by Arloing: Jour. de med. Vet. et de Zool. 1892, who succeeded twice and failed the third time with juice derived from parts of the same animal.

es made by inoculation with juice of apparently healthy flesh, involving 137 guinea-pigs. Nine of the researches furnish 13 positive results, that is, in one fifth of the cases the meat was infectious, and tuberculised 9.4 per cent of the guinea-pigs. He also finds that ingestion experiments have given 11.8 per cent of tuberculised animals a greater proportion than in the case of inoculation.

Cooking, if it can be assured adequate in practice, (which it cannot) will only reduce the nocuity by 50 per cent (Johne): from this fact on the basis of the 137 guinea-pigs aforesaid, Arloing calculates that one incompletely cooked tuberculous ox, would, as a minimum, infect 460 guinea-pigs, and all the tubercular oxen slaughtered in Lyons in a year, 2,300 guinea-pigs: it is impossible to state what the effect of the application of this reasoning to the human species might lead to, but, Arloing adds, until we can prove that this effect would be nil, we must act on the defensive.

As to the effect of the measure on breeders and butchers, it would of course be a source of annoyance, but much mischief would be prevented which now goes on unchecked; and even if the loss fall eventually upon the pocket of the consumer, he will have the satisfaction of knowing that he is paying for meat of guaranteed excellence. And the difficulty will soon pass away, for in the long run those measures most conducive to the public health are the most profitable to private individuals. Nor must it be forgotten that the health of the community
represents a very considerable sum in capital and wage. (+)

Moreover, the proposed partial seizure presents great practical difficulties; great responsibility is thrown on the individual Inspectors, whose standards, in spite of rules and regulations, may vary: so that a carcase may be passed easily in one market and seized in another to which it may be conveyed: this will lead to endless protests and disputes, with consequent expense, and the end will be no seizure at all (§). Therefore, total seizure is to be recommended for its expediency, and its easy and definite application.

Such Draconic measures will not disgust the public, but will have a salutary effect all round in leading to a closer inspection of the sources and liability of contamination of food substances in general.

The argument from statistics of deaths from tuberculosis in towns where total seizure is practised is scarcely a valid one, for the operation of the measure has been of too short duration to tell very materially on the number of cases.

At present there is little doubt that the weight of authority is in favour of total seizure. A resolution to that effect was carried with only three dissentients (⋆)

(+ ) A fact of which Governments take but little note: Dr Thresh remarks of the Recent Influenza Epidemic, "that had the country suffered from an epidemic among cattle, causing in the same time the same number of deaths and inflicting the same pecuniary loss, the alarm produced would have been greater and more permanent."

(§) It may be added that localised disease is rare in cattle (2 in 81 cases? Report of Committee of North of Ireland Branch, Brit. Med. Assoc. B. M. J. 1889, II p. 1412) and it is scarcely necessary to leave a loophole for so small a proportion, through which many others may improperly escape.

(⋆) Namely, Nocard, Laurent and Massa.
at the Congress on Tuberculosis in Paris (1888). It was embodied in the recommendations of the Departmental Committee of 1838, and of a Commission appointed by the Parliament of Victoria, 1886. And, though one does not often go to a Court of Law for the elucidation of scientific truth, the evidence with reference to the matter was ably threshed out in the now famous "Glasgow Meat Case". (+) Among those examined for the prosecution were Russell, LittleJohn, Robinson (of Greenock) Walley, Wallace, McFadyean, McCall, Goats, Cope and Cameron: while on the other side were Goldie, Imlach, Hime, Hill, and others. And Sheriff Berry in an able summing up of the evidence, concludes that "stripping" is "not a sufficient protection against the risk of communication of the disease by ingestion. There may be no appearance visible to the naked eye of the action of the tubercular bacillus in a particular part of the animal, and yet it may not improbably be there. Indeed the present case affords an illustration of the danger of inferring from the absence of symptoms visible to the unaided eye that the disease is localised.... On examination under the microscope, bacilli were seen in the pre-pectoral gland, a part of the animal which, although the carcase had been stripped would have been passed out into the market as fit for the food of man.

Such is the present state of evidence and opinion this important question.

As was remarked at the outset, legislation does not

(+) The Glasgow Local Authority against Hugh Couper and Charles Moore: before Sheriff Berry: May and June 1889.
yet seem practicable.

In this country chaos prevails: there is no uniformity, no concerted action, no efficient inspection or control; the list of experts given above as having appeared at the Glasgow trial, shows how opinions are divided among medical Officers of Health: and contradictory decisions are given by Justices (+). It is to be hoped that the Report of the Royal Commission now engaged upon the matter may recommend some means of dealing with tuberculous animals with justice to the breeder, the butcher, the consumer, and the rate and tax payer: for by no means the least difficult phase of the subject is the question of Compensation, into the incidence of which it is beyond the scope of this paper to enter.

It is obvious that the element of Compulsion must enter into any proposed measure: no option must be given to Local Authorities. In sanitary matters "Local Option" too often means Evasion, and there is no reason why Tuberculosis, if worthy of any preventive measures should be rated as less dangerous than smallpox and rabies.

Finally, it may be asked, Will any measures dealing with food substances do very much after all to lessen the amount of tuberculosis among human beings? It may be advisable to include tuberculosis of cattle and swine in the operations of the Contagious Diseases (Animals) Acts, or some modification of them: this will affect only the

(+): In the same Court within a few days; e.g. at Belfast see Lancet, 1889 II, p.363.
interests of the breeder and the butcher, for these Acts, beneficial though they are to animals do not (or at the least only indirectly) concern themselves with preventing the spread of disease to man. This question is one for the veterinarian and the agricultural economist. But, apart from some provision for the better inspection of dairies and animals in them with a view to the prevention and detection of tuberculosis, it seems unjust to tax the community, and to tax it somewhat heavily, to cut off what is, after all, a not very dangerous source of possible infection, the "healthy" flesh of animals with slight localised tuberculosis, while there remain the infinitely more serious sources of infection, and the immeasureably more frequent opportunities for it which occur in the intercourse of man and man, and the utter carelessness prevalent - through ignorance - almost culpable in a medical man - of the contagious nature of the malady, in dealing with the ordinary cases of phthisis, which are so frequent among us. The time has perhaps not yet come for preventing the marriage of persons suffering from tubercular diseases: nor, perhaps, can we hope to bring phthisis within the scope of the Infectious Diseases (Notification) Act. But in view of the enormous prevalence of tuberculosis, and the large part its ravages play in raising our death-rate, it is our duty to propagate a knowledge of the nature of the disease far and wide, and in such cases as we can, insist upon proper measures for preventing the spread of it being carried out.
CONCLUSIONS.

1. The ingestion of raw tuberculous matter from animals is capable of producing tuberculosis.

2. The ingestion of raw (or imperfectly cooked) meat from tuberculous animals may transmit tuberculosis.

3. The raw milk of tuberculous cows is always infectious when the udder is diseased, and should be used with caution in all cases: the infectious qualities are retained in butter, cheese, and other manufactured products.

4. Boiling of milk and adequate cooking of meat render the virus harmless: but the efficient carrying out of these measures is practically almost impossible.

5. It is the clear duty of the Legislature to cut off this source of danger to the community by providing for the proper inspection of dairies and slaughter houses, coupled with compulsory powers of seizure and destruction, with adequate compensation in proper cases.
CHAPTER VII.

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C. R. = Comptes Rendus de l'Academie des Sciences
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