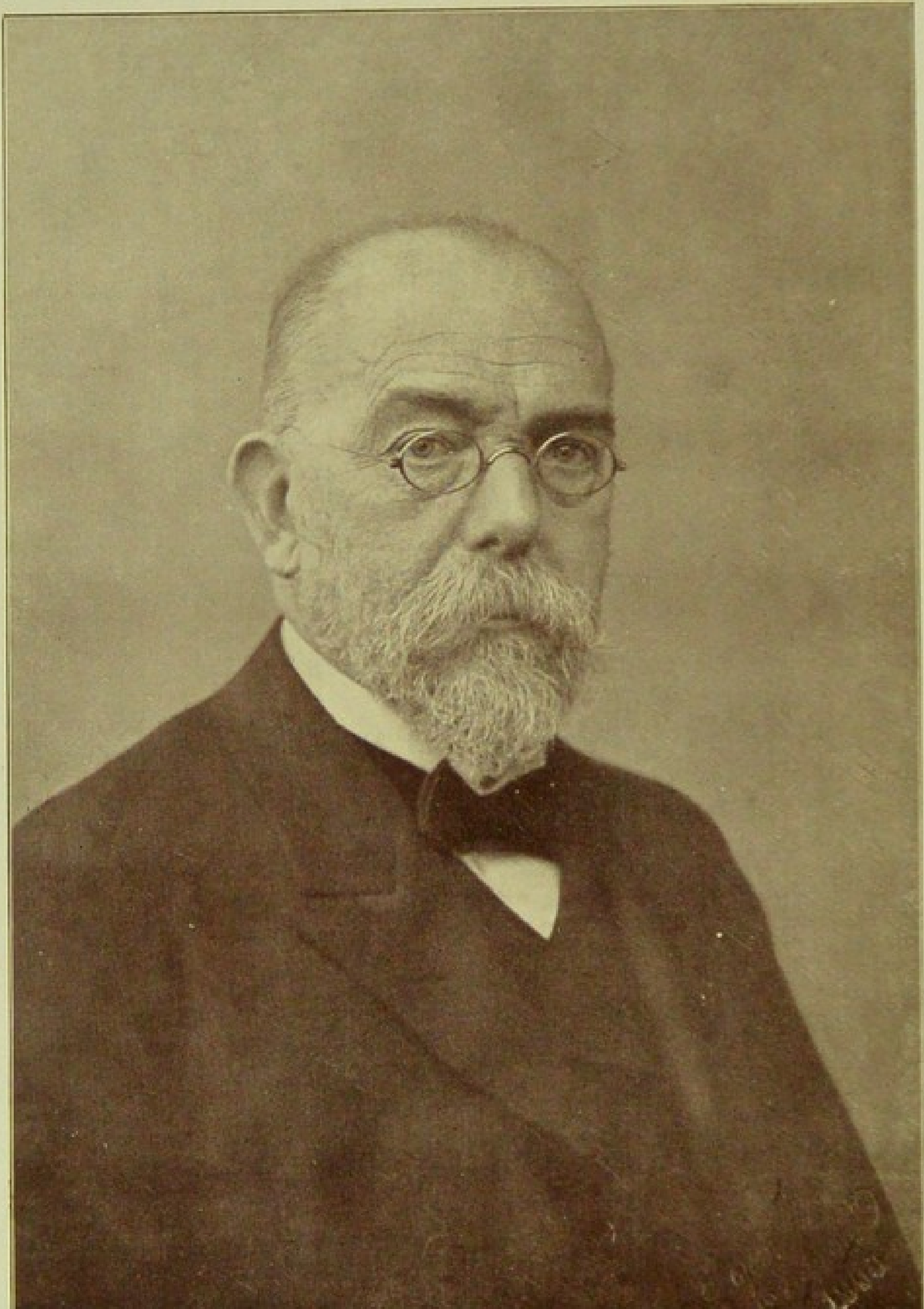


ROBERT KOCH.

(Born December 11th, 1843; died May 27th, 1910.)

Frontispiece]

BIBBY'S BOOK ON MILK.

BIBBY'S BOOK ON MILK

Section IV.

BOVINE TUBERCULOSIS:

CAUSE, CURE, AND ERADICATION.

A SUMMATION OF MATERIAL FACTS AND EMINENT OPINIONS FOR THE USE OF FARMERS, CATTLE-OWNERS, MILK-PRODUCERS VETERINARIANS, STUDENTS, AND OTHERS.

WITH APPENDICES ON THE DISEASES WHICH SIMULATE TUBERCULOSIS, ACTINOMYCOSIS AND JOHNE'S DISEASE; ALSO APPENDICES ON CALF MORTALITY AND THE DESTRUCTION OF RATS, AND A GLOSSARY OF TECHNICAL WORDS;

ALSO

WITH 80 ILLUSTRATIONS, INCLUDING 11 FULL-PAGE COLOURED PLATES AND 35 PORTRAITS OF EMINENT AUTHORITIES.

FIRST EDITION.

PUBLISHED BY

J. BIBBY & SONS, FEEDING EXPERTS, LIVERPOOL

Price: Ten Shillings Net.

Further Sections of this work are in preparation as follow :—

SECTION I.
Sampling and Analysis of Milk.

SECTION II.
Legal Points for Milk Retailers.

SECTION III.
The Care and Handling of Milk (from Cow to Consumer).

SECTION V.
Introduction to the Study of the Principles of Economic Feeding.

SECTION VI.
Points in Milking Cows.

SECTION VII.
Systematic Researches on Milk Production.

INTRODUCTION.

In issuing this little book to the public, it may be well to explain how it came to be written.

It has always seemed to us that in a world where action and reaction are equal and opposite it is well to endeavour to be of service to others, and especially to those who pay us our wages.

In pursuance of this ideal, it occurred to us some years ago that it would be a great convenience to our customers if we set apart a portion of our laboratory for analysing and testing the quality of milk from their own dairies ; and having the necessary facilities available, we offered to test, free of cost, any sample of milk produced on our customers' farms.

We were glad to find our offer was a timely one, as our patrons began at once to make free use of the opportunities thus put before them, and the result is that we have garnered quite a volume of interesting and useful information relating to the production of milk.

The immediate reason for publishing the book, however, is a labour-saving one.

Our laboratory manager, Mr. John Hanley, F.I.C., F.C.S., has had the management of this work, in which he takes a great interest. His correspondence with clients and others who seek advice and guidance in regard to maintaining the standard quality of the milk, has of late grown considerably, and the need has arisen for a handy volume in which an inquirer could find a full and complete solution of the various difficulties which are continually cropping up.

It is mainly to facilitate better and quicker replies to correspondents, arising out of these constantly recurring queries, that these pages have been compiled. It will be seen that the principal facts in connection with the analysis of milk have been carefully tabulated.

The volume represents a fairly complete record of information gleaned from our tests ; but in addition it will be seen that we have laid under tribute the work of most of the leading Dairy Authorities in the world, to whom we here express grateful acknowledgments.

We must add in conclusion that whatever credit belongs to the work is due to our laboratory manager, who has written and compiled the work himself and on his own initiative.

Our share, a very willing one, consists mainly in standing as a sort of godfather to it, and in blessing it with these few introductory words.

J. Bibby & Sons

King Edward Street,
Liverpool.

CONTENTS.

CHAPTER I.

CAUSATION AND IMPORTANCE.

CHAPTER II.

RELATIONSHIP OF HUMAN AND BOVINE TUBERCULOSIS.

CHAPTER III.

BOVINE TUBERCULOSIS.

CHAPTER IV.

WHAT IS THE EXTENT OF THE DANGER OF BOVINE TUBERCULOSIS TO MAN?

CHAPTER IV.—*continued.*

CHAPTER V.

THE CATTLE-OWNER'S STANDPOINT.

CHAPTER VI.

SUPPRESSION OF BOVINE TUBERCULOSIS.

CHAPTER VI.—*continued.*

CHAPTER VI.—*continued.*

CHAPTER VII.

PLAN OF CAMPAIGN.

CHAPTER VIII.

RESEARCHES IN PROGRESS.

APPENDIX A.

APPENDIX B.

APPENDIX C.

APPENDIX D.

APPENDIX E.

LIST OF PLATES.

LIST OF ILLUSTRATIONS.

PREFACE.

It is interesting and important to observe how, during the present generation, the one-time simple, pastoral, and peaceful work of milk production has been awakened by the critical attention of experts of so many professions. Chemists, bacteriologists, pathologists, veterinarians, hygienists, engineers, and legislators have contributed their quota of advice and guidance, thereby gaining something of renown. Surrounded by all these edifying influences, and beset by so many new obligations, the milk producer himself seems to have gained the least in distinction. He is merely the raw material upon which the teachers exercise their wits, and his docility under the process is a very apparent and fortunate condition for the masses who utilise the emblem of human kindness.

It is doubtful whether members of any other industry would have hearkened unto so much educative pressure without manifesting a growing sense of importance and self-assertion.

It may seem remarkable that we should attempt to deal with so technical a domain of the science and art of milk production as that of the present volume—mainly veterinary science. As will be seen, however, the subject is deeply involved with commonsense problems such as every enterprising farmer has to face, and we ourselves have had to deal with them, both directly in our own concern and indirectly in the voluminous correspondence a large business in intimate contact with the interests of milk production entails. As explained in the Introduction, we have been rather forced into the position of endeavouring to lay down a more or less systematic compilation of information, and it sometimes appeared to us that with so many good friends advocating both sides of a difficult and contentious subject, we might be able to state the case, however imperfectly, with some degree of impartiality, an office which, so far as we know, has not hitherto been attempted. On the one hand, the medical officer shows us how important a pure milk supply is for the health of the people, and on the other the farmer tells us how hard and ungenerous his landlord is respecting expenditure on sanitary improvements. It soon becomes evident that the adjustment of such questions merges in a wider and deeper issue demanding "more light" all round, and if our humble labours can contribute in a little measure the task will be richly rewarded.

The work has been materially lightened by the kind assistance, guidance, and encouragement we have received from a number of eminent authorities, notably Professors Bang, Orla Jensen, and C. O. Jensen, of Copenhagen; Professors Wallace (Edinburgh), Ernest E. Glynn, and Moore (Liverpool), Sir John M'Fadyean (London); also the following Medical Officers of Health: Dr. Hope (Liverpool), Dr. A. G. Anderson (Rochdale), Dr. Wilson (Lanark), and Dr. Robertson (Edinburgh). The assistance of Dr. C. Bolle, of Berlin, has been most valuable, and we have had much useful material pointed out to us by Alec. E. Wilson, Esq., of Belfast.

The unfailing courtesy of the Chief of the Bureau of Animal Industry (Dr. A. D. Melvin), Washington, U.S.A., is here gratefully acknowledged, as well

as the information received from a number of his able army of workers, notably Professor Ward, late of California, now struggling with Rinderpest in the newly-acquired Philippines. The names of the Health Commissioners of American cities who have kindly placed their records, regulations, and other information at our disposal are quite too numerous to mention.

During the progress of our writing, death deprived us of the kindly guidance of our former teacher, Professor Sir Rubert Boyce. " Be sure you give all your references " were his last words of injunction, and we have endeavoured to obey them. This strenuous investigator was a member of the Royal Commission on Tuberculosis. When the Report of the Commission was in the last stage of preparation—that monumental record of human genius and patient precision—and only a few days after his last message to us, Boyce suddenly passed away. Before our labours were concluded, death also claimed our good friend and adviser, Professor W. Owen Williams, Veterinarian at Liverpool University. We cannot tell how deeply we have felt the loss of the guidance of these two friends.

Our especial thanks are due to Herr P. L. Jörgensen for his capably conducted and tactful inquiries in Copenhagen.

BIBBY'S MILK LABORATORY,
WATERLOO ROAD, LIVERPOOL,
October 9th, 1911.

LIST OF ABBREVIATIONS.

6th I. C. on T. ..	Report of Transactions of the Sixth International Congress on Tuberculosis, Washington, D.C., 1908.
P. H. and M. H. S. ..	Public Health and Marine Hospital Service, Treasury Department. Hygienic Laboratory Bulletins are referred to.
Dr. Anderson's Rept. ..	Abridged Report on an Investigation as to the Conditions of the Cowsheds, Dairies, and Milk Supply, by A. G. Anderson, M.D., D.Sc., M.A., D.P.H., Medical Officer of Health, Rochdale, England.
Dr. Eastwood's Rept.	Dr. Eastwood's Report to the Local Government Board on American Methods for the Control and Improvement of the Milk Supply, 1909.
B. A. I.	Bureau of Animal Industry, U.S.A.
L. G. B...	Local Government Board. Only the Supplements containing the Reports of the Medical Officer are referred to.
Annual Rept.	Annual Report.
Trans. B. C. on T. ..	Transactions of the British Congress on Tuberculosis, London, 1901.
Dr. Stevens' Rept. ..	Dr. Stevens' (Medical Officer of Health, County of Renfrew) Report on Dairies, Cowsheds, etc., dated August 9th, 1909.
Dr. Orr's Rept. ..	Dr. Orr's Report on an Investigation as to the Contamination of Milk, carried out on behalf of the Councils of the County Boroughs of Bradford, Hull, Leeds, Rotherham, and Sheffield, and the Administrative Counties of the East and West Ridings of Yorkshire.
Rept Int. Com. on C. of B. T.	Report of the International Commission on the Control of Bovine Tuberculosis.
Jour. R. A. S. E. ..	Journal of the Royal Agricultural Society of England.

SECTION IV.

BOVINE TUBERCULOSIS:

CAUSE, CURE, AND ERADICATION.

NOTE.

A glossary of technical words will be found at the end of the book.

The small raised figures in the text are to be connected with the corresponding figures at the bottom of the pages as guides to footnotes of reference or explanation.

CHAPTER I.

CAUSATION AND IMPORTANCE.

WHAT IS TUBERCULOSIS?

TUBERCULOSIS is an infectious and contagious[1] preventable disease which affects man and all other mammals, *i.e.* cattle, sheep, pigs, dogs, horses, monkeys, rabbits, guinea-pigs, rats, etc., also birds, fish, and reptiles.

According to Nocard,[2] "there is no other disease in existence which attacks so many different kinds of animals." Lydtin denominates it "The universal panzootic."

A fleshy swelling in an underground stem has been for a very long time known as a tuber (Latin—*tumeo*, to swell). The Romance suffix (termination) "*cle*" indicates smallness, so that a tubercle is a small tuber. The older anatomists applied the term "tuberculum" to denote any small rounded outgrowth or prominence, and towards the end of the eighteenth century the word "tubercle" began to be applied to certain lesions or disease growths in the lungs.

In the following pages probably it will be observed that, occasionally, the subject diverges from a consideration of tuberculosis in bovines (animals of the bull species) to that of other creatures—usually man. For various reasons this is, to a great extent, unavoidable. **Historical**

Nearly all discoveries in pathology (the study of disease) have naturally been made in relation to the human species.

Seeing that there are no radical differences between human physiology and that of lower animals, the application of the same principles to both follows as a matter of course. Until results for the lower animal world are available, one cites the human experiences in the hope that the same treatment or method may prove useful when applied to bovines.

Newsholme[3] reminds us that "Hippocrates (460-377 B.C.) described the disease, ascribing it to a suppuration of the lungs which may arise in various ways. Galen (A.D. 130-200) also described it, and believed it so infectious that it was dangerous to pass an entire day in the company of a phthisical person. Hippocrates, Galen, Aretaeus (about 50 B.C.), and Celsus (about 30 B.C.) all described the disease, but not one of them appears to have recognised the existence of the tuberculous nodules, which form its characteristic lesion. With the discovery of these we arrive at the—

1. "In the present state of our knowledge, no useful distinction can be drawn between the terms 'contagious' and 'infectious.'"—Prof. Sir John M'Fadyean, Jour. R. A. S. E., Vol. 71, p. 37 footnote.
2. The Animal Tuberculoses, p. v. Trans. by Scurfield. Baillière, Tindall, and Cox, 1895.
3. The Prevention of Tuberculosis, p. 35. London, 1908, Methuen & Co. Dr. Arthur Newsholme, Medical Officer of Health to the Local Government Board, England and Wales.

"**Anatomical Period.**—Franciscus D. Sylvius (A.D. 1614-1672) was the first to recognise the causal relation of these nodules to phthisis, so that the first step towards accurate knowledge of its pathology may be said to have been due to the making of autopsies, which became fairly frequent in the seventeenth century. Sylvius thought the nodules to be the lymphatic glands of the lungs, and thus to be analogous to scrofulous growths. Much speculation was devoted to these nodules, and in the year 1700 Magnetus first described the more minute nodules known as miliary tubercles, comparing them to millet seeds, and showing their presence in the kidneys, liver, and spleen, as well as in the lungs. Morgagni (1682-1772) disputed the glandular nature of tubercles; Thomas Reid (1778) wrote of them as being not enlarged glands, but the products of exudation."

In 1793[1] Matthew Baillie published a detailed account of tubercles in the lungs, and stated they were the cause of pulmonary consumption, so common in England. The tubercles were so often compared in size to millet seed that the term "miliary tubercles" came into use.

Bayle (1774-1816) published, in 1810, the records of 109 autopsies on tuberculous patients, and traced the minute tubercles through the subsequent stages of pus formation and caseation.

Bayle's pupil, Laennec (1781-1826), made investigations and published teaching on tuberculosis, which has been well described, says Newsholme[2], as a *tour-de-force*.[3] He taught that every phthisis develops from tubercles, and that phthisis and tuberculosis are interchangeable terms. Scrofulous glands were merely tuberculosis confined to the lymphatic glands. He was very sceptical also as to the causation of tuberculosis by bronchial catarrh. In these respects modern pathology has, in the main, confirmed his marvellous insight.

The wasting nature of the disease gave rise to the term "consumption," and among pathologists the Greek term "phthisis" was used (*phthio*—I pine away).

The word "tabes" is of later origin, and also means wasting.

Pearl disease

In 1831 Gurlt[4] recognised the tubercular nature of the "pearl disease" (German—*Perlsucht*) of cows.

In 1857 Buhl found that the cheesy (caseous) material in the diseased lungs resulted from a ripening, as it were, of the grey tubercles.

Grapes.—In 1865 Villemin showed that inoculation of the tuberculous material from humans or from oxen suffering from "grapes" into rabbits, guinea-pigs, cats, and dogs caused the disease in the experimental animals. He thus established the infectious nature of the disease, and even went so far as to suggest that the infectious material was of the nature of a living organism.

1. Or 1794, according to the British Royal Commission, Second Interim Report, p. 51.
2. The Prevention of Tuberculosis, p. 36. London, 1908, Methuen & Co.
3. "Tour-de-force" = Feat of strength or skill.
4. Salmon, B. A. I., Bull. No. 38, p. 73.

Professor Louis Landouzy,[1] of Paris, points out that "All the labours of this French military doctor are summed up in this one sentence of his: 'Tuberculosis is caused by a morbid germ capable of multiplying in the organism. The inoculation of tubercle does not act through any visible or palpable matter that enters with this pathological product, but through a more subtle agent which is contained in it, and which escapes our perception.' Germ theory

"These facts and doctrines, showing the parasitic nature of tuberculosis, are just what we accept at the present day. All these have been, for the past forty years, contained in the work of the Val de Grace professor."

Chauveau and Cohnheim and Salamonsen confirmed and expanded Villemin's position. Cohnheim foretold the early discovery of the parasitic agent of tuberculosis, while Chauveau proved that tuberculosis could be produced by eating meat, etc., containing tuberculous material, and concluded that human and bovine tuberculosis were identical. Pasteur's work rendered it likely that tuberculosis was due to bacteria.

In 1882 Koch, whose recent death the world deeply deplores, described exactly the characters of the organism which he found in all tuberculous material. The organism has since been known as the *Bacillus Tuberculosis* and its discovery ascribed to Koch. Koch's discovery

This microscopic plant contains a poison, which acts in the animal organism in a manner not yet perfectly understood, but which, in great measure, is the cause of the power possessed by the plant in destroying animal life.

This disease assumes a number of forms, according to the part infected, and the progress attained.

Newsholme[2] tabulates the forms found in man as follows:— Forms of tuberculosis

General Tuberculosis .. Acute Miliary Tuberculosis Acute Tuberculosis	Names given to tuberculosis where many parts of the body are attacked simultaneously.
Phthisis .. .. .. Pulmonary Phthisis .. Pulmonary Tuberculosis .. Consumption	Tuberculosis of the lungs.
Tabes Mesenterica .. .. Tuberculous Peritonitis ..	Tuberculosis of the peritoneum and of the abdominal lymphatic glands.
Tuberculous Meningitis .. Acute Hydrocephalus .. Brain Fever (in part) ..	Tuberculosis of the membranes surrounding the brain.
Lupus	Tuberculosis of the skin.
Caries	Tuberculosis of the bone.
Scrofula[3]	Tuberculosis of the lymphatic glands.

1. 6th I. C. on T., Special Vol., p. 191.
2. The Prevention of Tuberculosis, p. 2.
3. "Scrofula"—one of the forms of the old "King's evil."

Consumption

The best known form of tuberculosis is human pulmonary consumption, in which the lungs are affected.

We shall not, in this connection, attempt to describe the progress of the disease from the pathologist's point of view, but the student who essays to study the question from the technical and economic standpoints soon finds the discussion involves him to such a degree that some notion of physiological and pathological processes is necessary to an intelligent inquiry ; hence we shall, briefly, and in a general way, outline the course which the disease takes, and the changes it produces.

Pathogenesis

The bacillus gains entrance into the animal body through the membranes which are continually kept moist by mucus, hence termed mucous membranes, and, less frequently, through the skin. Both the breathing passage to the lungs (respiratory tract), and the passage into and through the stomach and intestines, are lined with mucous membrane, and it is through these the organism gains entrance, but which is the more frequent portal is a matter of great contention at present. The point of arrest is termed the primary focus, and the organisms are carried from it by the currents of tissue fluid, either blood or lymph, continuously or by sudden flooding with large numbers.

One way which the bacillus gains entrance into the blood stream is, as explained by Delépine,[1] by ulceration of the walls of some veins passing through or at the side of some tuberculous focus ; tuberculous matter loaded with bacilli is thrown through the opening in the walls of the vessel into the blood stream and is distributed to all the organs of the body.

The battle of tubercle formation

"At this point two questions present themselves," says Wladimiroff.[2] "What are the means by which the tubercle bacillus makes its struggle in our living tissue for its own existence ? What weapons does the body possess by which this microbe may be defeated ? Like any other parasite, the bacillus of tuberculosis expects to make its living at the expense of the body in which it is lodged, abstracting the materials which it needs to sustain its life and enable it to propagate. In order to do this it assimilates, at all points on its own surface, whatever surrounding substances seem to it good. Many microbes excrete, at the same time, special poisons, which are injurious to the animal cells in their vicinity, and these latter cells, being disintegrated, serve in the nutrition of the microbe. The body, on the other hand, in order not to be exploited, poisoned, and destroyed, brings into action certain special cells endowed with mobility. These are the phagocytes of Metchnikoff. In a general way, we say that these combatant cells form two groups ; the smaller cells will be found in great numbers in the blood and in the other juices ; they are very active and always ready to attack microbes which invade the body. These are the cells which make what we call pus, and they attack

Phagocytes

1. The Lancet, Sept. 17th, 1898, p. 734.
2. 6th I. C. on T., Special Vol., p. 140.

the microbe with avidity. Meanwhile, the tubercle bacillus appears to resist their attack in a manner which is not yet quite clear, but perhaps by the aid of special substances which the bacillus produces. At any rate, when the little phagocytes succeed in enveloping or swallowing the bacillus of tuberculosis, they are still unable to digest it, but they keep it imprisoned until they themselves perish, victims of their own avidity.[1]

"The other group of phagocytes is made up of large and more sluggish cells, which usually do not attempt to devour the bacilli. These make their appearance in the second line on the field of battle, and form, with their own bodies, an inclosure around the microbes, preventing them from propagating in the body. This is their function in tuberculosis. While surrounding the enemy, they build up those little nodes—the tubercles—which have given their name to this malady. On the interior surface of this inclosure one also sees the larger phagocytes attack the bacilli, and often unite in numbers, forming 'giant' cells in which large numbers of bacilli are imprisoned. If the victory belongs to the cells of the body, the field of battle is not extended, and the wall about the imprisoned bacilli grows thicker by new cellular layers, and sometimes even by impregnation with lime. The bacilli, thus imprisoned, often remain for years in a state of quiescence (latency) before they perish. In vigorous people it is, perhaps, the general rule that the combat is ended in this way; but, unfortunately, modern life produces more of weakness than of vigour, and a diminished resistance against tuberculosis, the result of heredity, often puts us in line for a different issue of the struggle. The bacilli multiply with such speed and vigour that the defender cells are not able to circumvent them. The field of combat becomes larger. In order to flank this movement, larger and larger troops of combatant cells become necessary—so large that the body is not able to furnish adequate numbers. The line of defence remains weak and defective. The enemy can force it. The bacilli establish new foci, destroying more and more of the substance of organs necessary to life, and reducing them to useless material, to be eliminated from the body when circumstances are favourable. It is now that the abscess appears, the fistula, and, in the lungs, the large cavities."[2]

Tubercles

Latency

1. So that the bacteria are again free, "like the Greeks from the wooden horse, in the Siege of Troy."—Newsholme, The Prevention of Tuberculosis, p. 44.
2. It should be noted that Wladimiroff's brilliant and graphic description of the battle of tubercle formation is, in a few details, not exactly in accordance with the views of some other pathologists. The description refers to the conflict in which phagocytes are vanquished, but even in cases when these defensive cells are, on the whole, badly beaten, and an acute infection follows, a considerable number of the invading bacilli are destroyed. There are always losses on both sides, and the result is only determined by the relative strengths of the antagonists. On the other hand, "In some cases the bacilli die and disappear without leaving any lesions; in other cases the bacilli become dispersed throughout the body, where they may even multiply, sometimes to an enormous extent, but without producing any lesion" (British Royal Commission Final Rept., p. 26).

LESIONS OF TUBERCULOSIS.

Lesions

The Lesions of Tuberculosis.—When the tubercle bacilli have entered the body, and the leucocytes have failed to kill them, the character of the resultant lesion may be modified by :—

(1) The character of the bacilli—some have great parasitic power and increase rapidly in numbers, while other strains are more active in production of toxins.

(2) The number of the bacilli introduced.

(3) The character of the tissue, mainly in respect of its vital power of reaction. To a certain extent this is an hereditary condition.

As a matter of fact, both animals and people, in towns especially, frequently inhale and swallow the bacilli of tuberculosis.

The vast majority of inhaled bacilli are gradually washed upwards out of the bronchial tubes, swallowed, digested in the stomach, and nothing more is heard of them.

Were it the case that the entrance of tubercle bacilli to either the bronchial tubes or to the stomach would certainly be followed by tuberculosis, the world would now be empty of men and domesticated animals at least, if not empty of all animals, birds, reptiles, and fish! But it occasionally happens that these bacilli become lodged in the throat, in the bronchial tubes, or in the stomach, and are then, as it were, taken into the substance of the tissues. They may either remain there, and cause a local tubercular lesion, or, as is most frequently the case, they are carried off by cells along the lymph channels until they arrive at a lymphatic gland, where, again, they may be destroyed, or they may multiply and cause tubercular lesions in the gland; but many of them re-enter the lymph stream and attack other parts of the body, and so an invasion occurs.

When the tissues are unable to arrest the growth of the organisms the latter extend their growth by further invasion. This is known as proliferation. Frequently the tubercle bacilli are joined by pus-forming organisms, and a mixed infection occurs.

[1]"Wherever the disease is located, it is usually made manifest by the formation of a number of tubercles, the size of a pin head or smaller. If the tubercles are numerous and situated near to each other, they may become joined together in varying numbers, forming tubercular masses. Both the individual tubercles and the tubercular masses undergo certain changes by which they may become soft, cheesy, or semi-liquid, and in other cases they may become gritty or hard through the deposition of lime salts. By such changes a lymphatic gland may be greatly enlarged and filled with tubercular material, which, when cut across, is found to be calcified[2] and hard, or broken down and softened until it has acquired a cheesy or pasty consistency.[3]

1. D. E. Salmon, B. A. I., Bull. 38, p. 18.
2. "Calcified"—like lime.
3. This condition is known as caseation—cheesy formation.

Lung complications

"The tubercles which form in the lungs go through changes similar to those just described as occurring in the glands; but, owing to the different structure of these organs, there are complicating changes in the lungs which give the lesions a somewhat different appearance. The irritation caused by the tubercles usually leads to the development of bronchitis, with an abundant catarrhal secretion which fills the smaller air tubes, shuts off the air supply, causes the collapse of the lung tissue thus deprived of air, and leads to the depositing of yellowish cheesy matter in the air tubes and cells of this portion of the lungs. This condition is known as tubercular broncho-pneumonia."

It frequently happens that slowly growing tubercular nodules appear just below the shiny membrane which lines the chest and abdomen, and covers the contents of these cavities, and as time passes the nodules increase in number; many of these join together, and may form masses which hang from the part affected, and are called "grapes" or "angle berries," as they somewhat resemble in shape this fruit. The most remarkable thing about these growths is that enormous masses of them may be formed, and yet they seem to have no ill effect upon the animal! in fact, they are frequently found in the fattest of cattle! and in the opinion of the late Professor Owen Williams they do not damage the beef for food.

It may, however, happen in such cases that the animal—owing to exposure or over-driving—gets a chill, and there results a pleurisy or a peritonitis, and in consequence of this the shiny lining or covering previously mentioned breaks down, and the contents of the tubercles escape into the cavity; they there set up an acute tuberculosis, a spread of the organisms to all parts of the body, resulting in a high fever, a general blood-body poisoning, and rapid death.

Slaughter-house statistics of different countries of Europe indicate that about 9 or 10 per cent. of the cases of tuberculosis in cattle are in the generalised form, and the relative frequency with which the various organs and parts in bovines are affected is shown by the results of 430 cases in the abattoirs of Leipzig, recorded by Rieck,[1] as follows :—

Organs.	Per cent.	Organs.	Per cent.
Lungs	100·0	Muscles and inter-muscular lymph glands	49·3
Liver	83·0	Spleen	18·6
Intestinal Canal ..	73·0	Udder	16·7
Serous Membranes ..	57·4	Bones	8·8
Kidneys	52·5		

1. See Salmon, B. A. I., Bull. 38, p. 21.

PREVALENCE AND IMPORTANCE OF HUMAN TUBERCULOSIS.

Although we hope to show that bovine tuberculosis is a problem which calls for the closest attention of cattle owners, it cannot be doubted that its main importance depends upon its relation to the human disease, which [1]"....is the most terrible of plagues, demanding the largest sacrifices, and taxing life more heavily than all other calamities combined—sickness, war, and catastrophe. The sympathy of the civilised world is in this matter unanimous; all nations have combined in a common war against a common enemy."

"The mortality of tuberculosis is further emphasised," as pointed out by Cortelyou,[2] "when compared with the bubonic plague in India, which has not, since its first outbreak in 1896, caused as many deaths in that country in proportion to the population as were caused by tuberculosis in the United States during the same period. Statistics show that tuberculosis in the last four years caused more than three times as many deaths in this country (U.S.A.) as occurred in action and from wounds received in action during the entire period of the civil war."

[3]"All civilised peoples are beginning to realise that a certain vague and immense danger threatens them. There is a tendency to recognise that tuberculosis is the great modern scourge which has, in a certain sense, taken the place of the plague of ancient times" —a scourge which [4]"....through all historical time, has been man's most relentless foe in his attempts to improve his condition."

Commonest victims

It is a noticeable fact that although [5]"The disease in question is one of the few infectious diseases to which widely different species of animals are susceptible, its commonest victims are persons and dairy cows." [6]"It is the only known infectious disease from which, practically, no vertebrate[7] species is immune." "Tuberculosis," says Dr. A. G. Anderson,[8] "....is the most widely spread of all diseases affecting humanity, and still produces the highest mortality; still claiming its title as the 'captain of men of death' (Bunyan)."

The great white plague

Woodbury[9] says, however, that the "Great white plague.... causes more deaths than any other disease save pneumonia." It is sad to observe that [10]"Tuberculosis picks its victims at the very period when the value of life is a maximum after the investment in the

1. Dr. A. Wladimiroff, St. Petersburg, 6th I. C. on T., Special Vol., p. 134.
2. 6th I. C. on T., Vol. 5, p. 27.
3. Letulle and Rey, 6th I. C. on T., Special Vol., p. 222.
4. Vaughan, 6th I. C. on T., Vol. 4, pt. 1, p. 190.
5. E. C. Schroeder, P. H. and M. H. S., Bull. 56, p. 529.
6. Schroeder, B. A. I., Circular 153, p. 44.
7. "Vertebrate"—possessing a back bone.
8. Dr. A. G. Anderson's Report, p. 22.
9. William R. Woodbury, M.D., Boston, U.S.A., 6th I. C. on T., Vol. 3, p. 765.
10. Irving Fisher, Professor of Political Economy at Yale University, 6th I. C. on T., Vol. 3, p. 8.

education and preparation for life of the young is finished, and before the period of declining vitality sets in, when the productivity of the individual has become exhausted."

"Further allowance has to be made," as Newsholme[1] points out, "for the fact that consumption only causes death after prolonged disablement, and almost certainly causes a higher proportion of the total sickness than of the total mortality." **Economic loss**

Newsholme[2] goes into figures on the "....terrible national loss of money and efficiency" due to disablement by tuberculosis, without including cost of illness, interference with the work of others, which every sickness involves, or the infection of others, and resultant further loss of health and money.

Mayo[3] tells us that it "....affects the majority of civilised people at some time during their lives. As but 10 per cent. of the population die of it, we have a right to say that few serious diseases, not self-limited, tend more naturally to ultimate recovery than does tuberculosis. It is this tendency which renders it so much more favourable than malignant disease,[4] that those afflicted may be comforted with that greatest of all human blessings—hope." **Curability**

That the disease prevails to a much greater extent than we have positive knowledge of is shown by the calculations made by Philip,[5] who says that "....a reasonable basis for estimating the incidence of tuberculosis in any district, that is, in forms requiring attention, may be obtained by multiplying the recorded mortality from tuberculosis by 10."

That most people are affected with tuberculosis at some time in their lives is confirmed by Harbitz[6] and Unterberger.[7]

Schroeder[8] quotes the following figures for *post-mortem* examinations. Dr. Albin Burkhart,[9] after the examination of 1,452 human cadavers, found that 91 per cent. showed lesions of tuberculosis irrespective of the cause of death. Nägeli, from the examination of 500 cadavers, places the figure at 96 per cent., and Schlenker, from 100, makes it 66 per cent.

Harbitz[10] quotes the Norwegian medical writer, Andword, who argues from the extreme frequency of tuberculosis found by anatomical research in persons of all ages, even during the first years of childhood. He contends that fresh tubercles, in development, can be shown to exist in cases of sudden death, or of death from acute illness, in 8 per

1. The Prevention of Tuberculosis, p. 16.
2. The Prevention of Tuberculosis, p. 20.
3. Charles H. Mayo, A.M., M.D., Rochester, Minn., 6th I. C. on T., Vol. 2, p. 2.
4. "Malignant disease"—cancer.
5. R. W. Philip, M.A., M.D., F.R.S.E., F.R.C.P.E., Edinburgh, 6th I. C. on T., Special Vol., p. 251.
6. 6th I. C. on T., Vol. 1, pt. 1, p. 113.
7. 6th I. C. on T., Vol. 1, pt. 1, p. 141.
8. B. A. I., Circular 118, p. 15.
9. Zeitschrift für Hygiene, etc., Vol. 53, No. 1.
10. 6th I. C. on T., Vol. 1, pt. 1, p. 112.

cent. to 9 per cent. of the population. Thus, for instance, in a town of 210,000 inhabitants, 17,000 would be infected with tuberculosis.

Autopsy revelations

"Nägeli,[1] at Zurich, found in autopsies of children aged one to five that 17 per cent., and of children aged five to fourteen that 33 per cent., had tuberculous lesions."

Harris[2] found healed phthisis ("involuted tuberculosis") in about 38 per cent. of the *post-mortem* examinations made by him of persons over twenty years of age dying in the Manchester Royal Infirmary.

Coates[3] agrees that even with the most serious forms of tuberculosis spontaneous recovery takes place in half the cases. Austin Flint[4] takes a similar view.

Significance of autopsy revelations

On the strength of the above evidence, "....it has been assumed by some," says Newsholme[5], "that phthisis is so common and so often a non-fatal disease that every one is more or less exposed to infection, and that consequently infection can play only a very minor part in its causation. The evidence as to the percentage of the total population (say, roughly, one in every two) showing evidence of old tuberculous lesions is derived from hospital practice. Persons belonging to this type possibly form a majority of the total population, and although the proportion probably is smaller in other grades of life, we may assume, for present purposes, that the same proportion holds good for the general population in England and Wales. But it by no means follows that one-half of the total population at any given time is actively tuberculous and discharging tuberculous material. The fact that recovery has occurred, and the patients have died from other diseases or from accident, shows the absurdity of such an assumption. It is highly probable that the vast majority of those showing *post-mortem* these healed lesions were 'closed' cases, in which the micro-organisms could not escape; so that the patients were not infective even during a few months of their life. Further light is thrown on the point by a comparison between the deaths from phthisis and the population at each five- or ten-yearly period of life."

Basing his calculation on the commonly accepted supposition that for each death from phthisis during a given year, three other patients have been constantly ill with the same disease, Newsholme calculates from the Registrar-General's figures that the proportion of active infective consumptives in the general population is one for every 263 persons.

Tuberculin testing

A very different picture is presented, however, when we consider

1. Quoted by Newsholme, The Prevention of Tuberculosis, p. 363, from Dr. H. Méry, Rapports présentés au Congrès International de la Tuberculose, Paris, 1905, p. 298. The following three references are abstracted from Newsholme, Prevention of Tuberculosis, p. 49.
2. Brit. Med. Jour., Vol. 2, p. 1385.
3. Sanitary Jour., No. 189, p. 343.
4. Brit. Med. Jour., Sept. 30th, 1882.
5. The Prevention of Tuberculosis, p. 62.

the proportion of human beings who react to tuberculin, and are, therefore, tuberculous in some degree.

Thus Courmont[1] found 30 per cent. of subjects healthy in appearance to be tuberculous; among patients apparently not tuberculous, 35 to 40 per cent. Courmont quotes Beck, who observed in Berlin 46 per cent. positive tuberculin reactions in 2,000 patients who were apparently not tuberculous.

Calmette[2] says that his method of ophthalmo-tuberculin testing reveals that "....outside of hospitals, from 10 to 15 per cent. of all individuals supposed to be perfectly healthy really contain within them tuberculous lesions. The accuracy of the test has already been demonstrated by a considerable number of autopsies....."

Dr. Burton Rogers[3], of Manhattan, Kansas, U.S.A., confirms that "Statisticians agree that 10 per cent. of the people in civilised countries die of tuberculosis," while Mohler[4] raises this figure to 14 per cent. [5]"Every day yields its three thousand, each minute two lives, as a sacrifice to this plague."

The most important form of tuberculosis is that affecting the lungs.

Prevalence of consumption

Fisher[6] gives the following figures :—

NUMBER OF DEATHS FROM TUBERCULOSIS OF THE LUNGS PER 100,000 OF POPULATION.

Australasia	76
Belgium	109
England and Wales	114
Italy	118
Netherlands	136
United States	142
Japan	145
Jamaica	152
German Empire	183
Norway	197
Ireland	210
Servia	332
Austria	336

Koch[7] stated that mortality from tuberculosis was increasing in Ireland. It is encouraging to observe, however, from Dr. Hope's[8]

1. 6th I. C. on T., Vol. 1, pt. 1, p. 533.
2. 6th I. C. on T., Special Vol., p. 78.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 837.
4. John R. Mohler, A.M., V.M.D., Chief of the Pathological Division, Bureau of Animal Industry, U.S.A., P. H. and M. H. S., Bull. 56, p. 503.
5. Miss Kate Barnard, Guthrie, Oklahoma, 6th I. C. on T., Vol. 3, p. 800.
6. 6th I. C. on T., Vol. 3, p. 6.
7. 6th I. C. on T., Vol. 3, p. 809.
8. Dr. E. W. Hope, Medical Officer of Liverpool, 6th I. C. on T., Vol. 4, pt. 1, p. 175.

figures, that since 1904 there has been a slight but steady decline, though the increase between 1864 and 1886 was very pronounced and a high figure was maintained until the beginning of the decline in 1904, above mentioned.

Tuberculosis decreasing

Neither is this hopeful tendency confined to Ireland, for, as Pope[1] pointed out at the Sixth Congress, the authorities "....concerned with the suppression of tuberculosis among human beings can make the inspiring announcement that practically everywhere the disease is on the decline."

Can we suppress tuberculosis?

Notwithstanding these good signs, Wilson and Rosenberger[2] "....feel dubious as to the ultimate extinction of the disease by human means."

Anderson[3] takes the optimistic view, however, and looks forward to a time "....when cases of tuberculosis will be as rare in England as cases of smallpox are to-day."

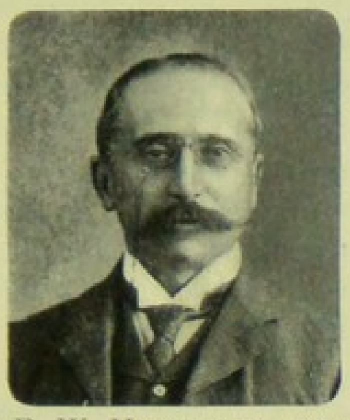
Sir Lauder Brunton[4] stated that "....it only requires proper preventive measures to be taken for this disease to be as rare in this country in twenty-five years as leprosy is to-day." [5]"An infant would have its expectation of life at birth increased by about two and a half years if tuberculosis were to disappear while other conditions remained unchanged."

England leads

"In England and Wales," says Newsholme,[6] "....over 60,000 deaths are still annually referable directly to tuberculosis, 11 per cent. of the total deaths from all causes at all ages. Of the deaths from tuberculosis, seven-tenths are caused by phthisis, and of the latter 77 per cent. occur during the working years of life, from twenty to sixty-five. Each death, furthermore, is preceded by a period of invalidity which, on the average, runs into years," but [7]"England prides herself that she was the first country to have special hospitals for consumption. They had four hospitals in London for many years before the matter was taken up by any other country." Philip[8] attributes the decline of the disease in England to the beneficent "....legislation of the past three-quarters of a century with regard to the dwellings of the poor, lodging houses, workshops, factories, and to other public health enactments that have paved the way for the more direct attack," so that "....England has continued for long to yield the lowest death-rate from tuberculosis. The progressive

1. Prof. Jesse E. Pope, East Orange, N.J., 6th I. C. on T., Vol. 4, pt. 2, p. 571.
2. 6th I. C. on T., Vol. 1, pt. 2, p. 610.
3. Dr. A. G. Anderson's Report, p. 4.
4. Public Health Congress, Birkenhead, 1910. See Birkenhead and Cheshire Advertiser and Wallasey Guardian, July 20th, 1910, p. 6.
5. Willcox. Quoted in Michigan Agricultural College Experiment Station Circular No. 8, p. 60.
6. 6th I. C. on T., Special Vol., p. 81.
7. Theodore Williams, M.D., F.R.C.P., London, 6th I. C. on T., Vol. 1, pt. 2, p. 943.
8. 6th I. C. on T., Special Vol., p. 248.

decline in the death-rate during the pre-bacillus period thus finds definite and sufficient explanation."



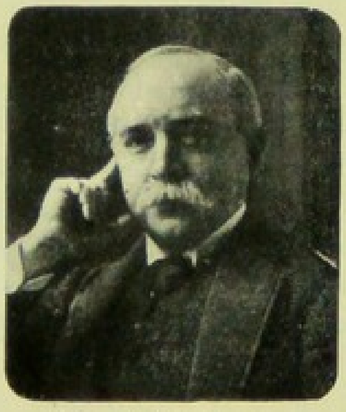
E. W. HOPE, M.D., D.Sc.
Medical Officer of Health for the City and Port of Liverpool. Professor of Public Health in the University of Liverpool. Examiner in Public Health to the Universities of Edinburgh, Manchester, and Liverpool, and to the Royal Sanitary Institute.

In view of this pre-eminent position of England, it would probably be hard to find a better record than in our City of Liverpool, in which the housing of the poor has received persistent, patient, and unwearying effort on the part of our medical officers, among whom Dr. Hope will not stand least in the noble work, fraught, as it is, with the vast difficulties of a seaport town and a deal of poverty, misery, and ignorance. **Work in Liverpool**

Hutchinson[1] points out that "To-day, those nations which have the highest rate of wages and the shortest hours have the lowest death-rate from tuberculosis." **Social conditions**

It is interesting to observe how the struggle with this great human plague has touched the deeper note in the serious and earnest workers.

Philip[2] says that "The anti-tuberculosis crusade is a world movement of first importance. Although of recent origin, it has already attained striking proportions. It is a fine expression of the large humanitarian outlook of modern life." He referred to the great International Congress,[3] at which he was speaking, as a remarkable illustration of the wide interest which has been awakened. **Humanitarian outlook**



DR. R. W. PHILIP
Edinburgh.

Bowditch[4] believed the proceedings to be of "....deepest import to humanity throughout the world," and that they might serve to [5]"....foster the beautiful spirit taught by the great and noble Pasteur, that science should bind nations together, making war and discord impossible."

It is not surprising then that we find Minor[6] appealing to our sociologists and philanthropists to step in and assist in the struggle in the case of the very poor and the criminal poor, whose habits and surroundings lie at the root of their sickness. "For them," he says, "the treatment of tuberculosis is primarily a sociological problem, and the doctor's part in it, however important, is necessarily secondary to that of the civic and social reformer." **Sociological problem**

1. Woods Hutchinson, A.M., M.D., New York, 6th I. C. on T., Vol. 3, p. 717.
2. 6th I. C. on T., Special Vol., p. 248.
3. 6th I. C. on T., Washington D.C., U.S.A., 1908, held under the auspices of the National Association for the Study and Prevention of Tuberculosis.
4. Vincent Y. Bowditch, M.D., Boston, U.S.A., 6th I. C. on T., Vol. 1, pt. 2, p. 579.
5. *Ibid.* p. 580.
6. Chas. L. Minor, Asheville, N.C., 6th I. C. on T., Vol. 1, pt. 2, p. 1020.

The psychic element

This thinker points out that "....since a patient has not merely a body, but a mind and soul, there are two distinct aspects in which this treatment (home treatment) can be regarded, the physical and the psychical, the former concerned with the arrangement of the details of the patient's life and surroundings, the nature of his exercise and rest, his dietary, amusements, occupations, etc.; the latter dealing with his mental capacity and his attitude towards his sickness, his spirit, courage, and will, and his relation to his physician."

"When I speak of will power," he[1] continues, "I refer not merely, or chiefly, to that more ordinary type of will which is able to impose its wishes upon others, but more especially to that higher type which can turn its will inward and conquer itself, which can force itself to the difficult denial of pleasure for profit, which can obey tedious orders strictly and closely, and which can compel cheerfulness when all around seems dark."

Phthisiophobia

Schroeder[2] deals with "....that inordinate fear of tuberculosis which has been discussed by many writers under the name of phthisiophobia,[3]" but which, for that reason, cannot be lightly dismissed, especially as even positive phthisiophobia has not been proven to be altogether unreasonable. It is regrettable that the protection of public health often necessitates the imposition of annoying and impeding restrictions that add to the cares of those whose lives are burdened with a serious disease. But what other course can we follow?

"Tuberculosis, unfortunately, is infectious, and the best way to escape it is to shun the virus to which it is due and to avoid the source from which this virus is expelled. A policy that attempts to characterise as anything better than extremely dangerous the sources from which the essentially necessary causative agent of an infectious disease that is responsible for more than 10 per cent. of all deaths is derived, is very shortsighted. To refrain, through motives of sympathy and charity, from imposing various irksome and disadvantageous restrictions on those who are the unhappy victims of tuberculosis is equivalent to making sentiment an apology for the sacrifice of thousands of healthy persons in the present generation and millions in coming generations to a deadly plague.

"When we actually realise the truth about tuberculosis and the number of victims that it claims, we are in a better state of mind to join those who may be classed as afflicted with phthisiophobia than those who seek to belittle the dangerous character of tuberculous individuals for their fellow creatures. During 1908, according to the most reliable figures obtainable, 160,000 human lives were prematurely ended by tuberculosis in the United States alone, and this enormous number does not include the deaths hastened by tuberculosis but

1. Chas. L. Minor, Asheville, N.C., 6th I. C. on T., Vol. 1, pt. 2, p. 1021.
2. 25th Annual Rept. B. A. I., U.S.A., 1908, p. 110.
3. Or "tuberculophobia," as H. S. Anders terms it.

chargeable to other immediate causes. Every one of these deaths was due to infectious material that had its origin within, and was expelled from, the bodies of tuberculous persons and animals.

"There is too strong a tendency at the present time to characterise the careful consumptive as not dangerous to those with whom he is associated. No doubt he is less dangerous than the careless consumptive, but we cannot afford to teach that the degree of danger he represents is so small that we can safely afford to disregard it. We must bear in mind that the infectious disease with which he is affected, according to the figures presented at the recent International Congress on Tuberculosis (1908), by the United States Public Health and Marine Hospital Service, destroyed 60,000 more lives in the United States last year alone than yellow fever destroyed in the United States during the whole of the last century."

Danger from consumptives

Schroeder,[1] ". . . . whose knowledge of tuberculosis and its mode of transmission is derived from years of special study, attempted recently to protect his environment from infection with such particles of material, emanating from his own body, in which tubercle bacilli are commonly expelled from the bodies of persons affected with pulmonary or laryngeal tuberculosis. The conclusions drawn from this attempt are in accord with the investigations of Bartel and Spieler,[2] who liberated a number of guinea-pigs in the dwelling of an intelligent, careful consumptive, who used a sputum flask to prevent spreading tubercle bacilli with the material he expectorated, and who, no doubt under the direction of the investigators, took every reasonable precaution to protect his environment from becoming infected with tubercle bacilli expelled from his body. A number of the guinea-pigs contracted tuberculosis from this exposure, thus proving that the environment of even a careful consumptive is by no means free from active virulent tubercle bacilli, and, therefore, is not safe.

"As some objection may be made to the quoted experiment because of the reputed high susceptibility to tuberculosis of the animals used, attention is called to the fact that guinea-pigs have been repeatedly shown at the Experiment Station of the Bureau of Animal Industry to be quite resistant to tuberculous infection unless the tubercle bacilli are injected directly into their bodies.[3] In one experiment seven healthy cattle and 98 guinea-pigs were exposed simultaneously for a period of about half a year to three tuberculous cows. The exposure was so severe that six of the seven cattle contracted tuberculosis, but 97 of the guinea-pigs remained healthy."

PREVALENCE OF BOVINE TUBERCULOSIS.

Bovine tuberculosis increasing

While we have the great satisfaction of knowing that among

1. 25th Annual Rept. B. A. I., p. 111.
2. Review in Hygienisches Centralblatt, Vol. 4, No. 11, p. 332, 1908. (Reference from Wiener klinische Wochenschrift, Vol. 20, No. 38, pp. 1144-50, 1907.)
3. 20th Annual Rept. B. A. I., 1903, pp. 61-8 ; 21st Annual Rept. B. A. I., 1904, pp. 44-65 ; Bull. 86, B. A. I., 1906, pp. 7-9.

human beings tuberculosis is, practically, everywhere on the decline, Pope[1] says that, thus far, all efforts to check the advance among domestic animals have, with few exceptions, failed; for "....in nearly all lands bovine tuberculosis, and hence tuberculosis of other animals, is on the increase."

This view is confirmed by the International Commission on the Control of Bovine Tuberculosis.[2]

Although, as Cary[3] points out, "Extensive and accurate statistics are wanting" regarding the prevalence of bovine tuberculosis, we have at our disposal a sufficiency of data to form a fairly accurate estimate. Jensen[4] considers that reliable information has been obtained partly from abattoirs and partly from the use of the tuberculin test.

United Kingdom.—The Secretary of the Central Chamber of Agriculture informs us that "With regard to the statistics as to the number of tuberculous cows, there are no means of getting any accurate information. On the 4th August, 1909, when the Scotch (Milk) Bill was 'reported' in the House of Lords, Lord Camperdown moved 'that further consideration of the Bill be postponed,' partly on the ground that, in reply to a question from him, the Government said they had no accurate statistics as to the number of tuberculous cattle in the United Kingdom, and partly because this want of information prevented the Government from giving any estimate as to the cost which the working of the Act would involve, if the Act were passed, that the Government found it advisable to withdraw the Bill."

According to Friedberger and Fröhner,[5] "It was found in England during the year 1892, when cattle were being slaughtered on account of contagious pleuro-pneumonia, that from 20 to 30 per cent. were tuberculous. The percentage in London was from 25 to 40, and in Edinburgh, Yorkshire, and Durham 19 to 23. The tuberculin inoculations in England in the years 1897-1900 gave an average of 25 per cent. of cattle which reacted" (were tubercular).

Mr. (now Sir) T. H. Elliott,[6] Secretary to the Board of Agriculture, in his evidence before the Royal Commission on Tuberculosis, 1898, stated that at least 20 per cent. of the cows in this country were tuberculous.

In 1901 Professor (now Sir) John M'Fadyean[7] stated that "We know that about 30 per cent. of all the cows giving milk in this country are tuberculous in some degree." This, he considers, an

1. 6th I. C. on T., Vol. 4, pt. 2, p. 571.
2. Rep. Int. Com. on C. of B. T., p. 7.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 544.
4. Milk Hygiene, p. 71.
5. Veterinary Pathology, Vol. 2, p. 348.
6. Rept. of the Royal Commission on Tuberculosis, 1898, Minutes of Evidence, qu. 179, p. 12.
7. Trans. B. C. on T., Vol. 1, p. 83.

"alarming proportion."[1] Newman[2] estimated that 20 to 30 per cent. of British cows were tuberculous.

The figures published by the Superintendent[3] of the Bellshill Slaughter-house, Lanarkshire, are interesting. We have summarised the figures for 1904 to 1908, inclusive, with the following results:—

	Number of Carcasses Inspected.	Per cent. Tubercular.
Oxen, Bulls, and Heifers ..	10,248	3·57
Calves	3,122	·77
Cows	2,179	30·38

Eager[4] quotes the report for 1906 of the Medical Officer of Health for London, showing that of 500 cows examined after slaughter by the City Veterinarian, evidence of tuberculosis was found in 46·8 per cent.

Delépine[5] found that in farms which had careful sanitation the proportion varied according to age from 20 to 31 per cent. in milch cows, and that on some farms from three-fourths to all of the cows were affected.

Delépine[6] concludes there are very few herds in this country free from tuberculosis, and the problem involved in this state of things is, according to Mr. C. R. W. Adeane,[7] one of the most important subjects that agriculturists have to face at the present time.

During the three years October, 1907, to October, 1910, Mr. John Malcolm,[8] Chief Veterinary Officer, Birmingham, in testing herds under their voluntary municipal scheme (see p. 305), found among 544 animals tested for the first time 168 reactors, that is, just under 31 per cent. Great variations were noted in the degree of prevalence. Thus, one herd of fourteen cows was found free, while in another case twenty-four animals reacted out of thirty-six (66·6 per cent.). Mr. Malcolm considers the figures representative for the district.

Likewise, Mr. C. W. Walker-Tisdale[9] gives us the results of testing done by the Wensleydale Pure Milk Society during 1910, and believes the figures are representative for small herds, except in that they do not all represent herds tested for the first time.

1. Trans. B. C. on T., Vol. 1, p. 85.
2. Bacteriology and the Public Health, 1904, p. 204. J. Murray, London.
3. 17th and 18th Annual Repts. County and District Medical Officer, County Council of Lanark, 1907, p. 272; 1908, p. 199.
4. P. H. and M. H. S., Bull. 56, p. 246.
5. Veterinarian, July and Aug., 1899.
6. 38th Annual Rept. L. G. B., Suppl., p. 402.
7. Mark Lane Express, May 9th, 1910, p. 555.
8. Private communication, dated July 28th, 1911.
9. Private communication, dated July 25th, 1911.

	Number of Cows tested.	Number Reacted.	Percentage Reacted.
Wensleydale district	334	55	16·46
Low-lying districts	123	38	30·80
Total	457	93	20·35

United States.—Dr. A. D. Melvin, Chief of the United States Bureau of Animal Industry, states that [1]"....10 per cent. of dairy cattle" and [2]"....3·5 per cent." of the total cattle in the country (U.S.) are tuberculous.

Schroeder[3] states "....that probably not less than 20 per cent. of our American dairy cows are, to some extent, affected with tuberculosis."

Pope[4] gives a table showing the number of cattle condemned among animals slaughtered and subjected to Federal inspection from 1901 to 1907, inclusive. The proportion of tuberculous carcasses rises gradually from 10 to 25 per cent.

Moore,[5] one of the greatest American authorities, has combined figures obtained from work done under the direction of the Commissioner of Agriculture of New York State and from private practitioners. He found 32 per cent. of dairy cattle tuberculous.

As a result of searching inquiries among veterinarians of the Southern States, W. H. Dalrymple, M.R.C.V.S.,[6] Louisiana State University and Experiment Stations, concludes that bovine tuberculosis is prevalent and apparently on the increase in that region.

"It is a well-known fact," says Mohler,[7] "that tuberculosis is the most serious disease with which the American farmer has to contend."

Denmark.—Jensen[8] says "The abattoir statistics of Denmark show differences in the prevalence of this disease. In Copenhagen 30 per cent. of the mature cattle are affected; the same is true in Odense, while Aarhus reports a greater percentage.

"In consequence of the results obtained from the tuberculin test, Bang regards it as probable that in Denmark half of the small herds of from one to nine members are free from tuberculosis, but only a fourth of the herds of medium size of from 10 to 49 animals are free, and of the large herds only a few are exempt. Concerning the proportions in certain herds, most of the animals may be healthy and tuberculosis limited to a few individuals, but usually the disease

1. 6th I. C. on T., Vol. 4, pt. 2, p. 504.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 506.
3. B. A. I., Circular 153, p. 41.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 571.
5. Pure Milk and the Public Health, p. 61.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 539.
7. 25th Annual Rept. B. A. I., p. 159.
8. Milk Hygiene, p. 71.

is more widely distributed, and, in large herds, often from 80 to 90 per cent., or even a larger number, are affected.

"The conditions in neighbouring countries are about the same. Tuberculosis of cattle, for example, is scarcely less extended in Sweden, North Germany, Belgium, and England than in Denmark, while it is less frequent in Norway and South Germany."

Pope,[1] points out that the 1907 report of the Co-operative Slaughteries of Denmark shows, in common with other European figures, the same trend of increase of the disease among hogs (Andelsbladet, April 3rd, 1908). (See also U.S. Dept. of Agri., Bull. No. 38.)

Since 1907, however, the figures are either stationary or show a slight decline.

Belgium.—Professor Heymans[2] tells us that in Belgium they have 2,000,000 cattle. Half of these are cows. As a result of fourteen years tuberculin testing, they found 400,000 cows were tuberculous—that is, 40 per cent. Of the other stock, 10 per cent. reacted.

German Empire.—The increase of tuberculosis among cattle in Germany is well shown by Ostertag's[3] figures of abattoir returns.

Leipzig.	
1888 ..	11·1 per cent.
1889 ..	14·9 ,, ,,
1890 ..	22·3 ,, ,,
1891 ..	26·7 ,, ,,
1893 ..	28·14 ,, ,,
1896 ..	32·93 ,, ,,
1897 ..	36·40 ,, ,,
1898 ..	35·50 ,, ,,
1899 ..	32·93 ,, ,,
1900 ..	35·29 ,, ,,

Schwerin.	
1886 ..	10·7 per cent.
1893 ..	26·6 ,, ,,

Berlin.	
1890-91 ..	11·5 per cent.
1899 ..	23·14 ,, ,,

Zwickau.	
1894 ..	26·6 per cent.
1899 ..	45·8 ,, ,,

Rostock.	
1895-6 ..	17·0 per cent.
1896-7 ..	24·0 ,, ,,

Bromberg.	
1892-3 ..	20·7 per cent.
1899-1900	29·3 ,, ,,

Ostertag estimates that among stall-fed cattle, excluding calves, at least 25 per cent. are tuberculous.

THE SPECIAL SUSCEPTIBILITY OF DAIRY CATTLE

Susceptibility of dairy cattle

Is an important feature in the problem. The Federal Statistics of the United States for 1900 showed nearly 5,000,000 carcasses of beef animals inspected, of which only about 0·11 per cent. were tuberculous. This figure is in singular contrast to those given for milking cows[4] (see p. 18).

Macewan[5] explains this susceptibility as due to the inbreeding resorted to for development of the milking qualities, and which

1. 6th I. C. on T., Vol. 4, pt. 2, p. 571.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 522.
3. Handbook of Meat Inspection, p. 605.
4. See Dawson, 6th I. C. on T., Vol. 4, pt. 2, p. 736.
5. The Public Milk Supply, p. 30. Blackie & Son, Ltd., 1910.

reduces the disease-resisting power. "Again, by constant and prolonged milking, the normal period of lactation is drawn out, so that many cows are scarcely dry before they have another calf, and are once more in full milk. This constant milking and calf production must throw a very great strain upon the animal's system."

Dr. William Watson[1] adopts this view of functional wear on the animal organism, but Delépine[2] states it is unsupported by proof. Bang also failed to confirm it (see p. 364), and states, as we shall see (p. 293), that the prevalence of tuberculosis is generally the greater the more frequently the stock is increased by buying cattle at fairs, and consequently the most infected parts of the country are those where a brisk trade in cattle is being done, and where buying and selling of cattle is common.

Russell and Hastings[3] confirm this, and add ". . . . the longer period for which they are retained, and the closer confinement to which they are subjected."

HOW LONG WOULD BE REQUIRED FOR ERADICATION?

We have already noted Sir Lauder Brunton's estimate that, with proper measures, human tuberculosis could be eliminated from England in twenty-five years (see p. 12).

Sir John M'Fadyean stated that he would extend the time considerably in regard to tuberculosis in animals.

"As tuberculosis is one of the strictly preventable infections, there is good ground for the belief," according to the International Commission on the Control of Bovine Tuberculosis, "that through the formulation and enforcement of proper regulations, the disease may eventually be entirely suppressed."

DETECTION OF BACILLUS BY DIFFERENT METHODS OF INOCULATION.

The most conclusive method of identifying any particular disease-causing micro-organism consists in implanting it in an animal known to be susceptible to the disease in question, and observing whether the animal develops the disease.

In the case of the tubercle bacillus, the guinea-pig, according to Nocard,[4] ". . . . is the subject *par excellence;* in it the inoculation of a particle of a tuberculous product causes, with certainty, the evolution of a tuberculosis, which inevitably ends with death after a period of time varying from three weeks to two or three months."

Intra-peritoneal injection

The inner lining membrane of the abdomen is known as the peritoneum. Having pierced through this membrane the peritoneal cavity containing the bowels and other viscera is reached. Naturally any disease virus introduced into this cavity is provided a good opportunity

1. See The Scottish Farmer, Nov. 19th, 1910, p. 1033.
2. Lecture at Knutsford. See The Chester Chronicle, Jan. 28th, 1911, p. 2.
3. Wis. Agr. Exp. Sta., Cir. of Information, No. 23, p. 3.
4. The Animal Tuberculoses, p. 73.

of infecting the animal. This is known as *intraperitoneal injection*, and as a result of it [1]"....the infection progresses most quickly."

Injection into cellular tissue

"The *injection into the subcutaneous cellular tissue* gives in the guinea-pig results almost as certain, but less rapid, than those of intraperitoneal injection ; it is especially indicated in the case of an impure product contaminated by germs, the development of which in the peritoneum might set up a suppurative inflammation or a rapidly fatal septicæmia."

THE LATE PROFESSOR ED. NOCARD.

Subcutaneous inoculation

Injection under the skin is known as *subcutaneous inoculation*. It "....usually has no effect on the adult carnivora, the pig, and the solipeds[2] ; there supervenes a more or less voluminous nodosity[3] which sometimes softens and ulcerates, but the lesion remains local and gradually disappears. In the rabbit subcutaneous inoculation does not succeed in all cases, and Hischberger, Gebhardt, and Vyssokowitz have shown that a dilution of tuberculous sputum, still certainly fatal to the guinea-pig, has no effect on the rabbit."

Intravenous injection

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

"It sets up in all the vascular organs (lung, liver, spleen, marrow of the bones, etc.) an eruption of minute tuberculous granulations, sometimes so confluent that death supervenes before anatomical tubercles have had time to form ; the spleen, liver, and medulla of the bones are absolutely crammed with embryonic tuberculous follicles, which are extremely rich in bacilli ; to the naked eye these organs appear simply hypertrophied, engorged with blood, and very friable, and no trace of tubercular nodules can be discovered by the most careful examination. After a few transmissions the animals succumb, in from fifteen to twenty days, to a veritable tuberculous septicæmia,[4] after losing one-third, two-fifths, or one-half of their weight."

Eye inoculation

"*Inoculation into the anterior chamber of the eye*, introduced by Cohnheim, is another very interesting method," Nocard[5] continues, "and succeeds equally well with both guinea-pig and rabbit. It is followed by a mild keratitis,[6] which disappears promptly, and afterwards, from the fifteenth to the twentieth day, the iris is seen to be covered with fine tuberculous granulations ; then, at the same time as the eye is swollen and troubled in a definite manner (it frequently

1. The Animal Tuberculoses, p. 74.
2. "Soliped" or "Solidungulate"—an animal whose hoof is not cloven.
3. "Nodosity"—a knotty protuberance.
4. "Septicæmia"—blood poisoning.
5. The Animal Tuberculoses, p. 77.
6. "Keratitis"—inflammation of the cornea of the eye.

undergoes purulent softening and always becomes atrophied), the parotid lymphatic glands become hypertrophied and indurated ; then, in order, the pharyngeal, inferior cervical, bronchial, etc., glands, and finally the animal dies with pronounced tuberculous lesions of the lungs.

"*The sub-epidermic inoculation* by means of pricks or scratches is never effectual. M. Chauveau has never succeeded in infecting the calf by this method.....

Inhalation

"The *inhalation* of tuberculous material, when it has been dried and reduced to a powder, is the most certain method of setting up a pulmonary tuberculosis identical with the natural disease, and is successful in most animals.

Ingestion

"*Ingestion* of tuberculous material may also produce tuberculosis ....But although tuberculosis can be transmitted through the digestive tract, it does not follow that it is a method as sure and as certainly reliable as inhalation, and, above all, injection into the cellular tissue, peritoneal cavity, or veins. Far from it. Ingestion only succeeds in giving tuberculosis when the ingested material is very rich in bacilli."

Turner's theory

Origin of the Bacillus Tuberculosis.—At least two writers have essayed to account for the existence of the bacillus. Dr. Pickett Turner[1] thinks it probable it has originated from the harmless Timothy bacillus (see p. 25) found on grass. The grass is eaten by bovines, and when these animals are deprived of light by domestication the Timothy bacillus, which gains entrance with the food, becomes a pathogenic parasite,[2] and is known as the *typus bovinus* of the *Bacillus Tuberculosis.* Turner further believes that the disease in bovines is the cause of the disease in all other animals,[3] including man, and contends [4]"....that it is logical, reasonable, and more than probable that, if we restore the lost actinism, the bacillus will again become a saprophyte," when [5]"We shall have completely extirpated the disease."

We may explain that parasites are organisms which attach themselves to and live upon other organisms, while saprophytes are those which can live on dead organic matter, either of animal or vegetable origin.

For a few years the Ziehl-Nielsen method of staining tubercle bacilli was believed to be specific for the organism. The principle of this method is that when the organism is killed, and dyed with the well-known crimson dye fuchsin, in presence of a little carbolic acid, the colour is retained with marked tenacity. So difficult is it to wash out again that it will even stand immersion in 25 per cent. sulphuric acid (a very severe test for any dye) for some time. If this process is tried on most other organisms, the colour is almost immediately

1. Tuberculosis : Its origin and extinction, p. 95, London, 1906.
2. Tuberculosis : Its origin and extinction, p. 95, London, 1906.
3. Tuberculosis : Its origin and extinction, p. 95, London, 1906.
4. Tuberculosis : Its origin and extinction, p. 87, London, 1906.
5. Tuberculosis : Its origin and extinction, p. 96, London, 1906.

discharged. In the case of tubercle bacillus, the colour is, therefore, "fast" to acid. **Acid-fast bacilli**

The cause of the acid fastness is the fat waxy substances which penetrate the bodies of the organisms.[1] When the fat and wax are removed from the bacilli by extraction with alcohol, and afterwards with ether, the tubercle protein, as thus obtained, takes the carbolic stain, but is no longer acid fast.

Rabinowitsch discovered acid-fast bacilli in butter,[2] while Jensen[3] says they may occur in milk, butter, and excrement of the cow; and it is not wholly disproven that such bacilli may appear in the milk before it is drawn. The bacilli here referred to are not tubercle bacilli.

Serious difficulties arise in totally accepting Turner's theory. As we shall show later, human tuberculosis is sometimes prevalent in the absence of the bovine disease—in Japan, for example (see p. 168). On the other hand, one finds the biological aspect is not unsupported by indications which, if not directly supporting Turner's theory, are at least consistent with it.

Thus Mohler and Washburn[4] found that the lesions produced by the injection of acid-fast bacilli found in hay and about the stables into animals resemble closely those developed following the injection of tubercle bacilli that have been sterilised. We have already seen (Section III.) that the lesions from sterilised bacilli closely resemble those of the living organisms, hence, the lesions from the acid-fast stable bacilli resemble those due to virulent tubercle.

Theobald Smith,[5] also Mohler and Washburn,[6] tell us that the changes which virulent tubercle bacilli undergo on prolonged subculture are loss of virulence and increased saprophytism. This behaviour is, however, general among pathogenic organisms.

The Royal Commission,[7] however, did not find "....that the bovine tubercle bacillus diminishes in virulence to any great extent when subcultured for long periods—in one instance for as long as 1,487 days." They also state that [8]"The human tubercle bacillus has not shown any alteration in cultural characters on prolonged subcultivation."

Just as tuberculin is prepared from the *Bacillus Tuberculosis*, Irimescu[9] prepared para-tuberculin with Möller's Timothy bacillus, and used it for the conjuctival test (see p. 261). He obtained 44 positive reactions to first instillations out of 45 surely tuberculous cases.

1. See Wladimiroff, 6th I. C. on T., Special Vol., p. 136.
2. See Anderson, B. A. I., Bull. 56, p. 180.
3. Milk Hygiene, p. 84.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 629.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 653.
6. 6th I. C. on T., Vol. 4, pt. 2, pp. 626, 627.
7. Final Rept., p. 5.
8. Final Rept., p. 7.
9. Rivist, Stiintel. med., 1907, Nos. 7 and 8. Cf. Centrlbl. f. Inn. Med., V. 29, 1908, p. 87; quoted by von Ruck, 6th I. C. on T., Vol. 1, pt. 2, p. 1197.

Newsholme[1] cites Kossel's remarks that "....opinions are not wanting that the treatment of experimental animals with saprophytic acid-fast bacilli—that is, by micro-organisms in no way identical with tubercle bacilli—has a protective influence against the infection by tubercle bacilli (Möller, Friedmann). I do not deny that the tubercle bacilli of the *typus humanus* are nearly related to those of the *typus bovinus* and that their origin may be traced to a common stock; but these are considerations for which sufficient foundation is wanting."

Newsholme[2] also insists that no variation in the virulence of the human disease has occurred since the early descriptions of Graves, Watson, Walshe, and Flint.

Calleja's theory

Dr. Camilo Calleja,[3] of Madrid, traces the evolution of the *Bacillus Tuberculosis* from Ferran's bacilli, which are somewhat similar to *Bacilli coli communæ* (see Section III.), and are non-acid-fast. Calleja says they can be transformed into Koch's bacilli and *vice versâ*, produce tuberculous processes on inoculation, and are found almost everywhere.

The illustrations of the appearance of the bacillus of tuberculosis, magnified about one million times, and which we reproduce (see p. 34), will convey a more concrete idea than a lengthy description.

It only remains for us to explain that as bacteria are colourless organisms, they are not particularly easy to see under the microscope except by special methods of illumination. For this reason, and to bring out structure and increase definition, bacteriologists usually stain bacteria with aniline or other dyes, hence, in our illustrations they appear red.

We wish to point out, however, that there is some doubt as to the correct classification of the organism in question.

Is the germ a bacillus?

Within a few years of Koch's discovery of the *Bacillus Tuberculosis* several pathologists announced their belief that the organism was not a bacillus, but, in fact, rather belonged to a higher group of fission fungi—the hyphomycetes, or mould fungi.

A. Coppen Jones[4] concluded, from the examples of true branching which he observed in the growth of tubercle filaments, that the organism should be classed with the filamentous fungi.

In a translator's footnote to Fischer's work on The Structure and Functions of Bacteria, Jones remarks (p. 153) that his investigations have since been corroborated by many other observers.

Jones[5] continues, "The suggestion made in 1895, that a saprophytic form of the bacillus would probably be found outside the animal body, has also been fulfilled through the discovery, by Moeller

1. The Prevention of Tuberculosis, p. 136.
2. The Prevention of Tuberculosis, p. 215.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 224.
4. Centr. f. Bakt., 1895.
5. The Structure and Functions of Bacteria, 1900, p. 153.

(Therapeut, Monatshefte, Nov., 1898), of a bacillus almost indistinguishable from the tubercle bacillus growing upon Timothy grass. Several other saprophytic and parasitic organisms having the closest resemblance to Koch's bacillus, but growing at low temperatures, have now been described, and leave little room for doubt that they, together with the organisms of mammalian and avian tuberculosis, are closely related members of the same family. They show branched filaments in cultures, and when injected into the living tissues most of them give rise to actinomycotic-like centres of radiating filaments, terminating in clubbed ends."

More recently, Foulerton[1] confirms the position in contending "....that the reputed *Bacillus Tuberculosis* is a parasite—or, more probably, represents several parasites—which has been placed erroneously amongst the bacteria or fission fungi," and that it is really a streptothrix, to which class the ray fungus, which produces actinomycosis (lumpy jaw), and other mould fungi belong.

In this country and the United States the term "Streptotrichosis" is preferred by pathologists, while on the Continent the older term, "Actinomycosis," is used. (See Appendix A, p. 409.)

Both refer to the same class of infection, however, caused by parasites which have been described at one time or another under at least five different generic names—Actinomyces, Streptothrix, Cladothrix, Nocardia, and Oospora. The three former are in current use.

True bacteria, we may explain, are propagated either by transverse fission (dividing by the growth of a septum) or spore formation, while a streptothrix increases by branching, which is more characteristic of vegetable forms in general. Foulerton maintains that the tuberculosis parasite increases by branching, though of an ill-defined character, and on this point his contention is mainly based.[2]

The very slow growth of the organism, and the difficulty of growing it outside an animal body, or under such conditions that the process could be observed, may easily account for biologists having made a mistake in its classification.

The point is an academic one, however, though it may be useful to keep it in view with the probability that its importance is not yet sufficiently realised.

Wladimiroff[3] considers "....the question needs investigation, for the solution of this problem is somewhat important from the view-point of the evolution of species."

1. The Milroy Lectures on the Streptotrichoses and Tuberculosis, delivered before the Royal College of Physicians of London, on Feb. 17th, 22nd, and 24th, 1910, by Alexander G. Foulerton, F.R.C.S., Eng., D.P.H., Camb., Lecturer on Bacteriology and on Public Health to the Middlesex Hospital School, and County Medical Officer of Health for East Sussex. See The Veterinary News, March 19th, 1910.
2. Marion Dorset has also described branched forms of tubercle bacilli observed in cultures. See 18th Annual Rept. B. A. I.
3. Dr. A. Wladimiroff, St. Petersburg, 6th I. C. on T., Special Vol., p. 135.

Obligatory parasite

We shall continue, however, in this little work, with the term "*Bacillus Tuberculosis.*" Of more importance in this connection is the fact that [1]"....the bacillus of tuberculosis is not able to multiply except in the interior of a living organism. There are two reasons for this. In the first place, it cannot grow except at the temperature of the blood; and in the next place, it cannot find the special conditions of nutrition required by a cellular body so complex as the tubercle bacillus. These two conditions can be realised artificially in the bacteriological laboratory, but never in inanimate nature. It results, therefore, that the bacillus of tuberculosis is an obligatory parasite, a fact which has capital importance in the war against tuberculosis. Our strategists should never lose sight of this fact, that the tubercle bacillus can propagate nowhere except in the bodies of individuals sick of the disease, and that it is able to infect new individuals either directly or indirectly through the media of one's surroundings."

1. Dr. A. Wladimiroff, St. Petersburg, 6th I. C. on T., Special Vol., p. 136.

CHAPTER II.

RELATIONSHIP OF HUMAN AND BOVINE TUBERCULOSIS.

KOCH'S POSITION.

According to Park and Krumwiede, Junr.,[1] "Although differences in virulence were noticed in material from man and cattle, and had been noticed even before the discovery of the tubercle bacillus, they raised no doubt as to the complete identity and intercommunicability of the disease."

Sydney Martin

In his observations for the British Royal Tuberculosis Commission of 1895, Sidney Martin showed that tuberculous sputum from man was far less virulent for animals than was bovine tubercular material. Salmon,[2] having reviewed Martin's work, remarks that "It could not be said from these experiments that human tuberculosis was not communicable to cattle, but only that it was communicated with difficulty, and when it was communicated the disease remained localised and did not end fatally."

These observations appear to have been the first relating to differences between human and bovine tuberculosis.

Theobald Smith

In the Twelfth and Thirteenth Annual Reports of the Bureau of Animal Industry (1895-6), Theobald Smith, then a worker of that famous American Government Department, drew attention to marked differences between certain qualities of mammalian tubercle bacilli.

Robert Koch

The work attracted Koch's attention and, as a result, he stated certain conclusions at the British Congress on Tuberculosis, London, 1901. Restated in Washington, 1908,[3] as follow :—

"(1) The tubercle bacilli of bovine tuberculosis are different from those of human tuberculosis.

"(2) Human beings may be infected by bovine tubercle bacilli, but serious diseases from this cause occur very rarely.

"(3) Preventive measures against tuberculosis should, therefore, be directed primarily against the propagation of human tubercle bacilli."

The main point to be inferred from these pronouncements was that, in relation to human tuberculosis, the bovine disease was a negligible factor.

Immediately the world of experimental pathology stirred itself to a momentous activity, with the result that, in 1908, although Koch was unshaken in his views, he stood almost alone.

1. Collected Studies from the Research Laboratory, Dept. of Health, City of New York, Vol. 5, 1910, p. 3.
2. B. A. I., Bull. 38, p. 74.
3. See Koch, 6th I. C. on T., Vol. 4, pt. 2, p. 645.

Concerning Koch's statements of 1901 and 1908, Ravenel[1] says "In 1908, in Washington, Koch shifted his ground very materially, holding only that bovine tuberculosis did not cause *pulmonary* consumption in the human being. He, however, prefaced his conclusions with the statement that they were practically the same as those announced by him in 1901, and to the world in general this meant that he maintained the stand taken by him at that time. Even so-called scientific men have been misled by this statement, and have lost sight of the fact that in 1901 Koch practically denied the danger of tuberculous milk to the human race."

It should be clearly borne in mind that in this lies the whole crux of the question. How does man become infected with tuberculosis? Does it originate with the bovine, or is it propagated and disseminated by men themselves? Certainly, bovines are affected with the disease to about the same extent as men, and our close association with these animals, by our using their uncooked milk as an important article of food—one of the few animal products used by civilised man in the uncooked state—strongly suggests, at first sight, a causal relationship between the two.

The problem having been attacked from many different directions, the trend of investigation indicates that the relationship of human and bovine tuberculosis is by no means so simple and obvious as might appear. Though a vast amount of evidence in refutation of the technical points raised by Koch has been in evidence, the great master has passed away from us leaving the broad issue quite unsettled.

Mohler[2] says "The latest researches into the question of intertransmissibility of tubercle bacilli from various sources have shown that Koch's doctrine, enunciated in 1901, is not warranted. Variations do occur among tubercle bacilli, as among other forms of bacteria, but they are not constant.

"It is well known that Koch demanded, as a criterion of the animal origin of tuberculosis observed in man, the proof that cattle, when injected with human tubercle bacilli, will contract tuberculosis. Decisive proofs of such infection have now been obtained, not only by the German Commission on Tuberculosis, which was appointed at Koch's request, but also by the Royal English Commission, besides numerous French, Dutch, English, Scandinavian, Austrian, and American investigators.

"In fact, there have been so many instances on record of bovine tubercle bacilli having been recovered from human tissues, and of instances of butchers and others receiving accidental infections of the skin directly from bovine lesions, that it appears entirely proven that man is susceptible to tuberculosis caused by bovine bacilli.

1. Rept. of Second International Congress on Alimentary Hygiene, 1910, Vol. 1, Sect. 3, p. 49.
2. John R. Mohler, V.M.D., Chief of the Pathological Division, Bureau of Animal Industry, U.S.A., 25th Annual Rept. B. A. I., p. 157.

"This view was crystallised in a resolution adopted by the International Congress on Tuberculosis held in Washington, D.C., as follows :—

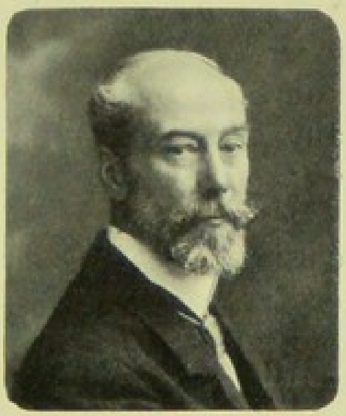
"RESOLVED.—That preventive measures be continued against bovine tuberculosis, and that the possibility of the propagation of this infection to man be recognised.

"While the presence of bovine tubercle bacilli in human beings is seen to be not infrequent, no definite conclusion can be drawn at present as to the extent of such infection, owing to the lack of data on the subject.

"But the fact that tubercle bacilli of one species may be transmitted to an animal of a different species, or to man, makes it apparent that any preventive methods for controlling tuberculosis, to be successful, must take into consideration all species of animals which are susceptible to tuberculosis."

The extent to which human beings are infected by bovines involves a somewhat lengthy discussion, with which we shall deal in the following pages; but at this point we shall only refer to the geographical distribution and relative frequency of the disease. If humans derive their infection from bovines, we should expect that where human tuberculosis was of frequent occurrence the bovine disease would also be rife, and that uncooked milk was used as an article of diet. Let us see if bovine and human disease go hand in hand.

In Ireland human tuberculosis is very prevalent, but the bovine disease is not by any means rife. The Department of Agriculture and Technical Instruction for Ireland[1] inform us "The information so far available on the subject supports the view that tuberculosis has only a very limited degree of prevalence among the cattle in this country, which number about 4,700,000 head."



MATTHEW HEDLEY, F.R.C.V.S.

Chief Inspector Veterinary Branch Department of Agriculture and Technical Instruction for Ireland.

"On the Island of Jersey," says Bang,[2] "where bovine tuberculosis is almost unknown, human tuberculosis is said not to be very rare; and the same is the case in many regions of Norway and other countries."

[3]"Regarding the conveyance of tuberculosis in the colder countries, Cobb points out that an absence of tuberculosis does not necessarily follow the absence of milk from the dietary. He shows, on trustworthy evidence, that the Alaskan Indian, including the Esquimo and Aleut, is the victim of consumption of the lungs to a great and increasing extent, though these people do not use to any extent milk of any kind as an article of diet, and cow's milk not at all."

1. Private communication, dated Dec. 10th, 1910, No. 5670-10.
2. 6th I. C. on T., Special Vol., p. 217.
3. J. M. Eager, P. H. & M. H. S., Bull. 56, p. 246.

Additional facts on this point will be quoted later (see p. 167), and we believe are sufficient to prove that the important pronouncement laid down by Koch was not without good foundation. In the considerations which follow we submit that the main question is not whether it is possible for man to be infected by bovine tuberculosis, but whether the latter is actually the main source of the human disease.

We shall now return to inquire into the degree and significance of the differences first observed by Theobald Smith between the types of *Bacillus Tuberculosis* found respectively in men and bovines.

At the Sixth Congress Koch pointed out that [1]" Of all human beings who succumb to tuberculosis, eleven-twelfths die of consumption, or pulmonary tuberculosis, and only one-twelfth of other forms of the disease.[2] One would have expected, therefore, that those investigators who are interested in establishing the relations between human and bovine tuberculosis would have searched for bacilli of the bovine type preferably in cases of pulmonary tuberculosis. This, however, has not been the case. Evidently animated by the desire to bring together as many cases as possible of bovine tuberculosis in man, they have investigated particularly cases of gland and intestinal tuberculosis, and have neglected the much more important pulmonary tuberculosis."

In the conclave of the world's greatest authorities, Koch[3] asked " Has any one of the gentlemen present ever seen a case of phthisis where, for any long period of time, bovine bacilli have been coughed out by the patient ? I would specially ask the question whether any case of pulmonary tuberculosis exists in which tubercle bacilli of the bovine type were found, not once, but repeatedly."

A few cases were mentioned, but Koch rejected them as inconclusive. He conceded that [4]"....bovine infection can occasionally occur," and " ....desired not to be understood as disregarding the endeavours to extirpate bovine tuberculosis, as far as these endeavours are dictated by agricultural and economic reasons," but that "....it would be wrong to give to these proposals the leading place in front of the efforts to combat human tuberculosis."

The assembly showed a desire to induce Koch to yield his position somewhat, and acknowledge a greater importance than he had hitherto attached to bovine transmission to man. His Excellency declined to recede one iota, however, from the position he had impressed earlier in the Congress, when he stated that [5]" The gist of it is—and I beg you to take note of it—that, up to date, in no case of pulmonary

1. 6th I. C. on T., Vol. 4, pt. 2, p. 650.
2. Bradford states that " The suppression, however, of other forms of tuberculosis is of equal importance."—6th I. C. on T., Vol. 2, p. 204.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 742.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 754.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 650.

tuberculosis has a tubercle bacillus of the bovine type been definitely demonstrated" (in human pulmonary tuberculosis).

On referring to the Report of the last Royal Commission[1] for a reply to Koch's question, we find they examined fourteen cases of pulmonary tuberculosis conclusively proved to be primary cases by *post-mortem* examination. In all of these only the human type of bacillus was found, thus far confirming Koch. They also examined twenty-eight cases which were probably primary cases, seeing that no evidence of tuberculous disease could be discovered during life in any other part of the body. Two of these proved to be cases of bovine infection; but as no *post-mortem* could be obtained in either case, it is not quite certain they were primary cases.

Arguing from these two rather inconclusive cases, the Commissioners[2] conclude that the bovine bacillus may be solely responsible for certain cases of pulmonary tuberculosis (consumption).

It seems difficult to doubt the correctness of the view as precisely laid down by Koch, but the question immediately arises as to whether the position embraces the vital issues which may reasonably be deduced from it. For how long, for instance, will a bovine bacillus gaining access into a human retain its characters as a bovine bacillus, and thus be recoverable and identifiable as such?

Many such questions arise in a critical investigation into Koch's position, and it would appear that the pathologists are hardly contesting the exact principle laid down by Koch, though, admittedly, a more important one reasonably deducible therefrom.

The discussion has resolved into one of the transmissibility of bovine tuberculosis to man, which Koch plainly tells us he has never denied. Notwithstanding, many authorities deal quite calmly with Koch's "mistake."

If a mistake, it has at least been a fortunate one, having drawn a vast amount of attention to an important evil.

Chas. F. Dawson, M.D., D.V.S.,[3] of the Delaware College Experiment Station, Newark, Delaware, U.S.A., says that "A summation of the views of various authors shows a preponderance of opinion against Koch's theory. Indeed, it would seem, while Koch's statements have generally failed to create converts to his theories, they have served to call the attention of the whole professional and lay world as well to the great prevalence of cattle tuberculosis, and to the question of its transmission to man. Therefore the agitation has been productive of an immense amount of good, and has served to interest our lawmakers, who, heretofore, have generally regarded the question with suspicion, and those who agitated it as faddists. Of equal importance has been the effect of Koch's statements upon the scientific world. Coming, as they did, from such an eminent authority on tuberculosis,

1. Final Rept., p. 12.
2. Final Rept., p. 13.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 735.

pathologists at once began to investigate tuberculosis with renewed vigour and from every conceivable standpoint. So that to-day this terrible scourge of man, and of our principal meat-producing animals, is receiving the attention from pathologists that its tremendous importance demands."

The investigation of tuberculosis from "every conceivable standpoint" does not appear to include the precise standpoint laid down by Koch, as we may judge from his words (p. 30); moreover, the decrease in the human disease while, at the same time, bovine tuberculosis is increasing is a serious difficulty in regarding the latter as the source.

DIFFERENCES BETWEEN HUMAN AND BOVINE TYPES OF THE BACILLUS TUBERCULOSIS.

The differences observed may be broadly stated as under :—

The Human Bacillus		The Bovine Bacillus
In appearance is delicate, slender, and curved.	Morphology	In appearance is short and straight.
Is less virulent for animals than the bovine type.	Pathogenicity	Is highly virulent for animals.
When grown in glycerinated beef tea, produces more acid than bovine type.	Biological	When grown in glycerinated beef tea, produces less acid than human type.

The last Royal Commission,[1] however, concluded that this latter characteristic of formation of acid by the human bacillus is ". . . . merely a striking indication of luxuriance of growth," and they were unable to deduce more from it than ". . . . from the luxuriance of growth itself."

Morphological Difference.

Stated thus, the differences seem well defined and diagnostic. The question immediately arises, however, whether they always persist, and even if they do persist, are they sufficient to justify a clear differentiation into two separate species.

As Smith[2] originally pointed out, "Varieties have been found among nearly all of those specific forms of pathogenic bacteria which have received a considerable amount of attention." Schroeder[3] states that "The term 'varieties' is here clearly used to designate differences of a kind to be expected among the individuals of a large and widespread species, such differences as we know to occur among

1. Second Interim Report, p. 27.
2. 12th and 13th Annual Repts. B. A. I., 1895-6. Jour. of Experimental Medicine, Vol. 3, New York, 1898.
3. 25th Annual Rept. B. A. I., p. 133.

organisms higher than bacteria and with a wide geographic distribution. There is a distinct parallelism between a wide geographic distribution of higher plants and animals and the number and kinds of hosts a pathogenic bacterium may infect; hence, there is no reason why the tubercle bacillus, which has received more attention and which affects more species of animals and more individuals than any other bacterium, should not have been found to include many different types, the extremes of which would leave us in doubt as to their specific classification if they were not connected by a chain of transition forms."

Transition forms

The fact is, however, that many transition forms have been found—forms which seem midway between those defined above for bovine and human bacilli.

Such variant, anomalous, transition, otherwise atypical, strains of tubercle bacilli have been isolated from cases of equine tuberculosis and human lupus and described by the British Royal Commission.[1]

"Mohler and Washburn,[2] after a comparison of many tubercle bacilli from different sources and a careful search of the literature, concluded that the more the subject is studied the more numerous the instances become in which bacilli of special types are found occurring naturally in animals far removed from the species which may be supposed to be their natural host. They obtained cultures of tubercle bacilli from human lesions that were morphologically and biologically bovine types, and in their summary of the investigations of others, they show that bovine types have frequently been obtained from man and human types from cattle. These investigators,[3] after a prolonged study of the susceptibility of tubercle bacilli to modification, draw the conclusion 'that the morphology of tubercle bacilli is their most variable characteristic.' They successfully changed the morphology and also the virulence of tubercle bacilli in the course of their investigations, and found it possible both to reduce and increase the virulence of tubercle bacilli for different species of animals.

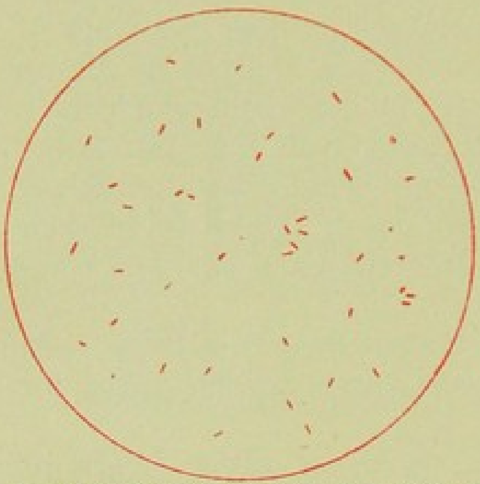
Variability

"As examples of changes in morphology, the following are instructive and interesting. A tubercle culture isolated from sputum was given a more perfect so-called 'human' morphological character than it originally possessed by passing it through cats. The same culture was given a perfect so-called 'bovine' morphological character by passing it through cattle. A culture isolated from a tuberculous boy was found to be morphologically a bovine type; after fifteen generations, on artificial media, it was still bovine in character; by passage through cats it became morphologically a human type. A culture isolated from bovine tuberculous lesions was found to be morphologically a bovine type; it became morphologically a human type, by growth on solidified human blood serum. It is reasonable

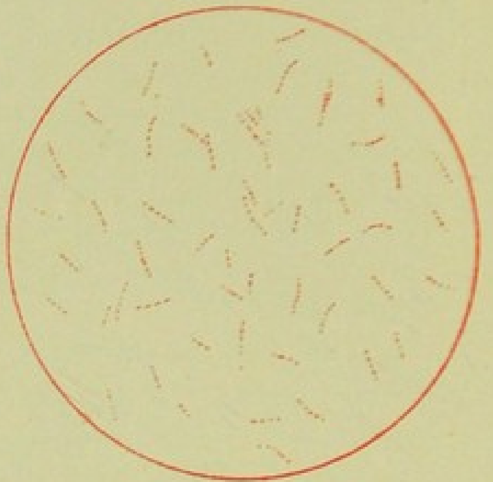
1. Final Report, p. 30.
2. Schroeder, 25th Annual Rept. B. A. I., p. 133, quoting Mohler and Washburn, Bull. 96, B. A. I.
3. 23rd Annual Rept. B. A. I., 1906, pp. 113-63.

Reproduced from 25th An. Rpt. Bur. Animal Industry, U.S. Dept. Agr., 1908. By kind permission of Dr. A. D. Melvin.

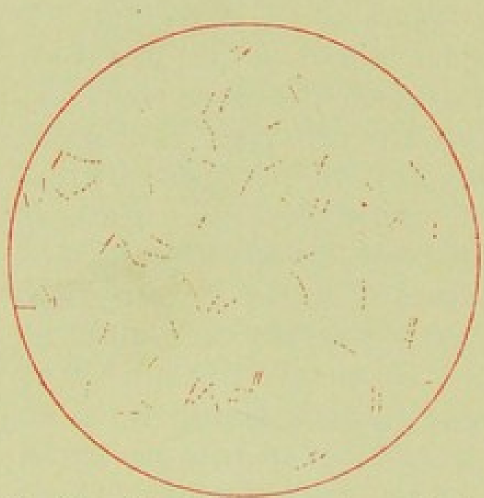
PLATE I.



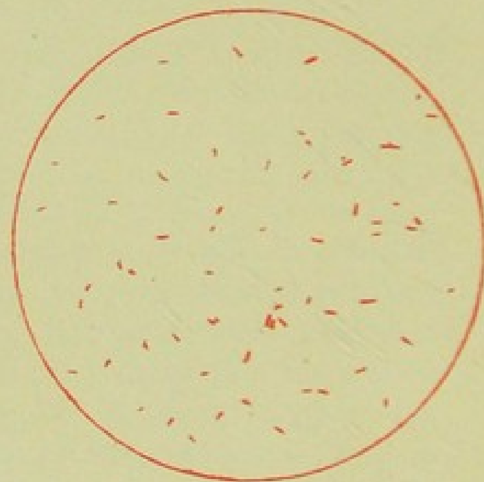
1.—Tubercle bacilli of bovine type originally obtained from cow affected with generalised tuberculosis.



2.—Tubercle bacilli shown in Fig. 1, changed to human type by growth on solidified human blood serum.

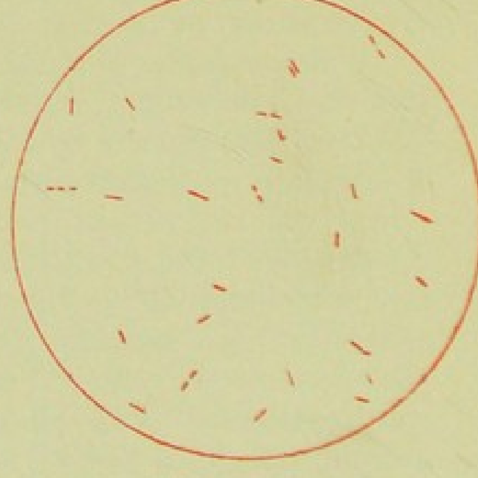


3.—Tubercle bacilli of human type originally obtained from human sputum.



4.—Tubercle bacilli shown in Fig. 3, changed to bovine type by passage through cattle.

5.—Tubercle bacilli of human type originally obtained from a man.



6.—Tubercle bacilli shown in Fig. 5, changed to bovine type by passage through a sheep.

EXAMPLES OF THE CHANGEABILITY OF TUBERCLE BACILLI FROM HUMAN TO BOVINE TYPES AND VICE VERSA.

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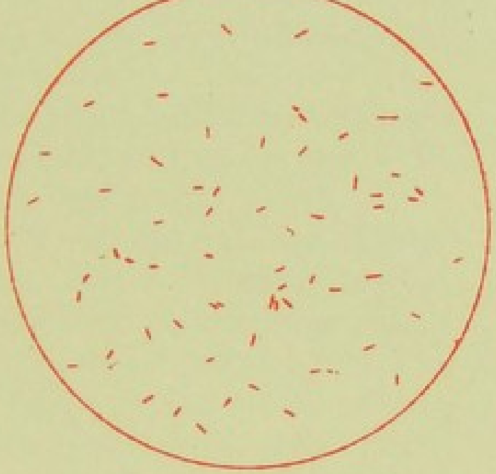
PLATE II.

HUMAN TYPES

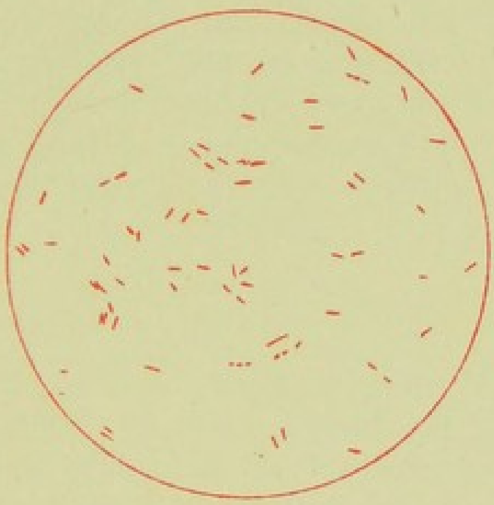
BOVINE TYPES.

Man (sputum).



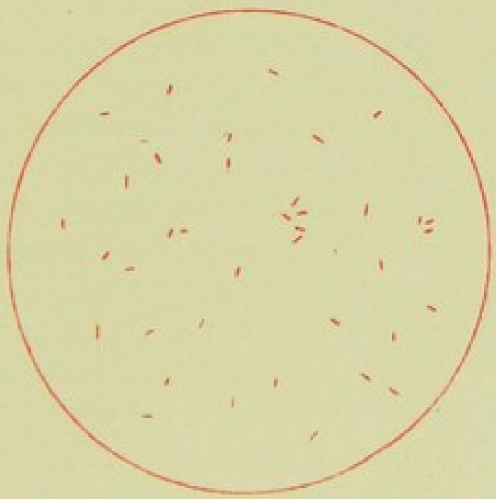
Man (sputum).

Girl.



Boy.

Cow.



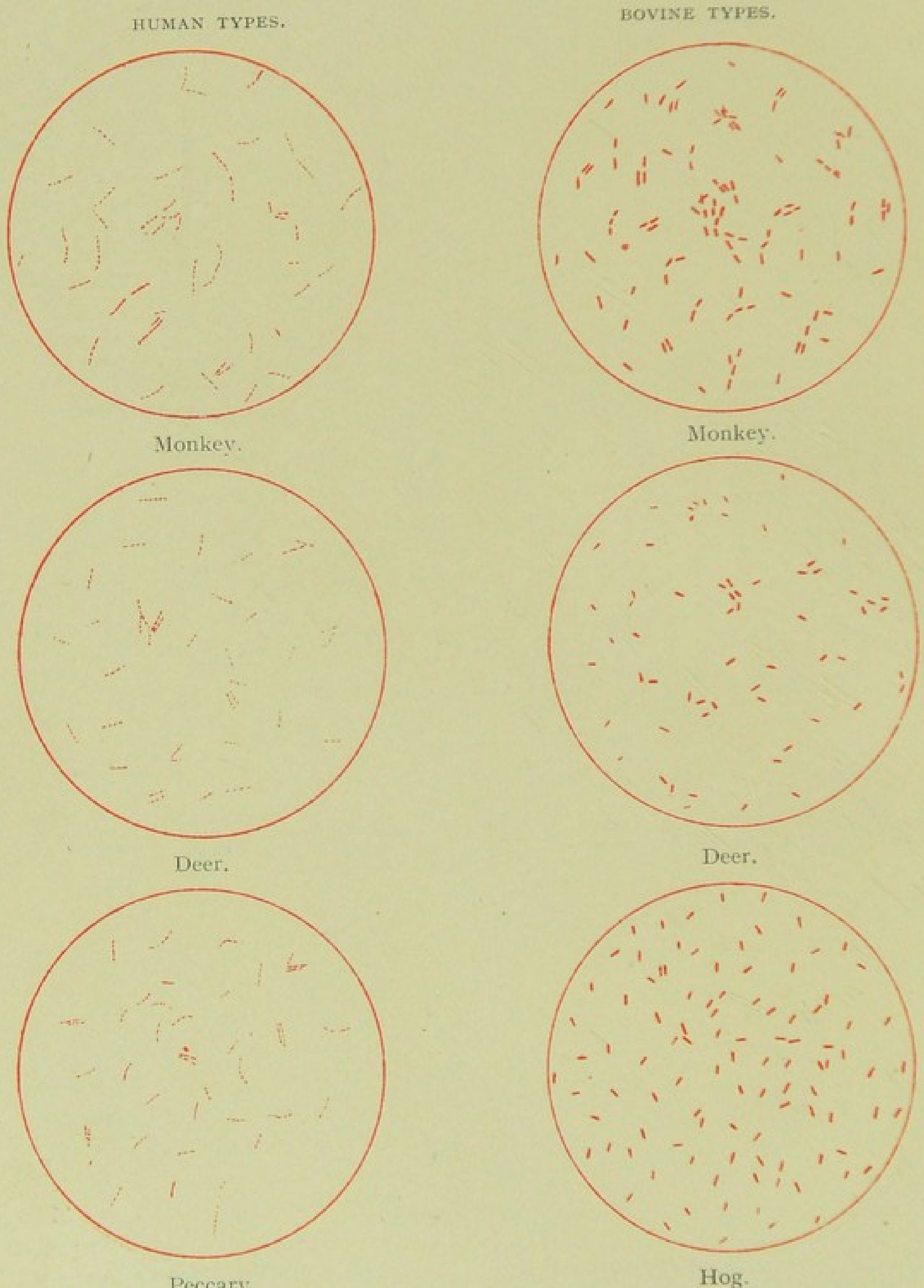
Cow.

TUBERCLE BACILLI OF HUMAN AND BOVINE TYPES FROM SIMILAR SOURCES.

(The original source is named under each figure.)

Reproduced from 25th An. Rpt. Bur. Animal Industry, U.S. Dept. Agr., 1908.
By kind permission of Dr. A. D. Melvin.

PLATE III.



TUBERCLE BACILLI OF HUMAN AND BOVINE TYPES FROM SIMILAR SOURCES
(The original source is named under each figure.)

to assume, if human blood serum can effect this change in a morphologically bovine tubercle bacillus from a bovine source, that the residence of tubercle bacilli from bovine lesions in the human body may likewise cause a change from so-called bovine to so-called human morphology.

"The morphological instability of tubercle bacilli is strikingly shown by the accompanying illustrations (Plates I., II., and III.), reproduced from the works of Mohler and Washburn.[1]

"Plate I. shows that it is possible to change tubercle bacilli from the so-called human type (which is long, relatively thin, beaded, and occasionally slightly curved) to the so-called bovine type (which is relatively short and thick and not beaded), and *vice versâ*. Plates II. and III. show how surprisingly dissimilar the morphology of tubercle bacilli from different sources may be—from the thick, short germs that were obtained from a hog to the thin, beaded threads that were obtained from human sputum." In the face of such evidence as that presented by Mohler and Washburn, one cannot rely upon the morphology of the *Bacillus Tuberculosis* as being sharply and persistently defined into human and bovine types (*typus humanus* and *typus bovinus*). The discussion evidently resolves into one regarding transformability of the one type into the other. Further experimental work is quoted by Dawson.[2]

Transformability.

The affirmed transformability of the human and bovine types of *Bacillus Tuberculosis* is ascribed by Mohler[3] to some constituent of the human blood; while in another paper by this distinguished authority, in collaboration with Washburn,[4] it is pointed out that "The slow but gradual transformation of certain growths of tubercle bacilli should not be considered such an impossibility. Other forms of bacterial life yield to the peculiar influences of their environment; and why should not the tubercle bacillus be equally susceptible to change? The attenuation of the *Bacillus anthracis* by submitting it to elevated temperatures, and the prompt recovery of its primary virulence by passage through a white mouse, affords a notable instance of the manner in which one of the most dangerous and active pathogenic micro-organisms may be transformed. The diphtheria bacillus becomes promptly attenuated by the addition of a small amount of iodine trichloride to the nutrient medium in which it is growing. Swine erysipelas becomes much less virulent by repeated passage through rabbits. The *Streptococcus pyogenes* and the bacillus of Asiatic cholera rapidly become affected while growing artificially, through the

Attenuation

1. 23rd Annual Rept. B. A. I., 1906.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 738.
3. 25th Annual Rept. B. A. I., p. 157.
4. Mohler and Washburn, 25th Annual Rept. B. A. I., p. 173.

action of the products of their own growth, and unless removed frequently to fresh nutriment will gradually weaken and die.

Instability of type

"Since, then, it must be admitted that there are many forms of pathogenic micro-organisms that can be materially altered by increase of heat to their surroundings, by the application of the direct rays of sunlight, by increasing or decreasing the acidity or the alkalinity of their nutriment, by the influences of the products of their own growth, and by passage through animals either susceptible or resistant to their action, is it too much to suppose that tubercle bacilli may also be altered in form, virulence, and in vigour of growth, when cultivated under unusual conditions? Experiments have shown that some tubercle bacilli may be transformed in form, pathogenicity, and cultural characteristics as well. More than this, cultures which seem incapable of attacking certain species of test animals with the degree of severity which one would expect in view of their average virulence for animals of other species, may be brought to change their peculiar affinities until they prove virulent for a species of animal formerly resistant."

"That these two types stand very near to each other," says Theobald Smith,[1] "cannot but force itself upon the attention of all who study them at close range. We know that they have a common toxic basis in tuberculin, and probably come from a common ancestor; but the question whether the two types have become so specialised by adaptation to different hosts as to have lost the capacity for being transformed one into the other is still unanswered."

The British Royal Commission made a number of attempts to transmute the bovine bacillus into the human bacillus, and *vice versâ*. "Most of these attempts failed altogether, a few only were equivocal; we found indeed," the Commissioners[2] continue, "that under the conditions contrived by us, both types of bacilli remained remarkably stable, alike as regards their growth on artificial media and their virulence for animals. Thus, we are inclined to regard transmutation of bacillary type as exceedingly difficult if not impracticable of accomplishment by laboratory procedure, though in view of certain instances in which we obtained from one and the same human body both types of bacillus, we are not prepared to deny that the transmutation of one type into another may occur in nature."

According to Park and Krumwiede, Junr.,[3] "Damman and Müssemier claim to have completely changed the type of a sputum culture by passage through goats. They used five goats, and give the impression of a gradual change which is not proven by the facts.

"De Jong reported a like increase in virulence after residence in a goat for three years and 145 days."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 653.
2. Final Report, p. 36.
3. Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, p. 119.

Eber[1] also considered that he had increased the virulence of viruses obtained from seven cases of human pulmonary tuberculosis by passage through calves (see p. 40). Park and Krumwiede, Junr.,[2] however, consider that the work is not convincing, and that the apparent increase in virulence indicating a transition towards the bovine type was really a weeding-out process on a mixed culture, the bovine fraction surviving. The same explanation is offered for three cases of apparent transmutation recorded by the Royal Commission. Concerning Eber's cases, these observers state that "The least convincing fact is the uniformity with which apparent change has taken place. In fact, if such change were so rapid and uniform, we wonder how any one has ever been able to isolate a single bovine virus from man." Park and Krumwiede, Junr.,[3] also reject certain observations of Lewis as not being true cases of transition, while Duval's results are unique and require corroboration. "The evidence in favour of rapid change of type," they conclude, "is incomplete and inconclusive."

It must be conceded that as our knowledge of bacteriological technique has become more exact, our belief in transformation of type of bacteria has gradually declined. A good example of this is afforded by the researches of our last British Royal Commission on the stability of character of the tubercle bacillus (see p. 23). Loss of virulence, as already mentioned, certainly occurs, and lost virulence may be recovered. Some minor changes in the behaviour of saprophytes is also known, but the evidence for real transformation of species of bacteria general is doubtful.

Pathogenic Difference.

According to Raw,[4] the most scientific method of distinction between the bovine and human types, but which, nevertheless, is not at all free from error, is that suggested by Koch—the susceptibility of animals to inoculation.

Ravenel[5] maintained, in 1902, that the susceptibility of the pig and guinea-pig to both types of the bacilli is so great that it is hard to distinguish between them.

Alexander[6] experimented with rabbits to determine their susceptibility to human and bovine tubercle bacilli, and to investigate the susceptibility to the different modes of infection. He found the smallest active dose to be—

1. Quoted by Park and Krumwiede, Junr., Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, p. 151.
2. Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, p. 120.
3. Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, p. 134.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 782.
5. Quoted by Newsholme, The Prevention of Tuberculosis, p. 125.
6. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 7.

	Of Human Bacilli.	Of Bovine Bacilli.
By inhalation	50,000	100
By feeding	quite inactive	5 doses of 10 mg. each.
By intravenous injection	50,000	50

The highest doses which caused no ill effects were—

	Human.	Bovine.
By inhalation	25,000	50,000
By feeding	180 milligrammes[1]	50 milligrammes.
By intravenous injection	8,000,000	5,000

Dinwiddie[2] concludes, from his own experiments, that human tuberculosis has less virulence for sheep, pigs, and rabbits than bovine bacilli. Schroeder[3] extends the list to include all the quadrumana.[4]

"Gorter,[5] after a careful study of tubercle bacilli from human and bovine lesions, found seven among twenty-one cultures from human sputum, which he regards as identical with the transition forms between human and bovine bacilli, which, he says, are described by Rabinowitsch. He concludes that human and bovine bacilli are not different varieties, and that the conversion of the one type into the other actually occurs."

"Eber,[6] of Leipzig, studied tubercle bacilli derived from eight fatal cases of human tuberculosis. The eight strains of bacilli obtained were found, on inoculation, to be two strongly virulent, two slightly virulent, and four non-virulent for cattle. The several strains were recovered from the tissues of the inoculated cattle and re-tested, and it was found that the two slightly virulent had become strongly virulent, and that two of the non-virulent had become slightly virulent for cattle. Eber concludes from this that an attempt at a sharp differentiation of the tubercle bacilli that occur in human tuberculous lesions into those that are and those that are not virulent for cattle, soon encounters difficulties."

Biological Difference.

Theobald Smith[7] recommends study of the reaction curve (formation of acid in glycerinated beef tea—otherwise bouillon—expressed graphically by a curve on paper—see curves for tuberculin reaction

1. = 2·777 grains.
2. R. R. Dinwiddie, M.D., Prof. of Pathology, Tulane University, New Orleans, 6th I. C. on T., Vol. 4, pt. 2, p. 686.
3. E. C. Schroeder, Superintendent of the Exp. Sta. at Bethesda, Maryland, of the U.S. B. A. I.; see 6th I. C. on T., Vol. 4, pt. 2, p. 606.
4. "Quadrumana"—four-stomached animals.
5. Review in Zeitschrift für Tuberkulose, Vol. 11, No. 3, pp. 260-1, 1907; also Review in Internationales Centralblatt für die Gesamte Tuberkulose-Forschung, Vol. 2, No. 1, pp. 12-13, 1907; quoted by Schroeder, 25th Annual Rept. B. A. I., p. 135.
6. Zeitschrift für Infektionskrankheiten, Parasitärkrankheiten u. Hygiene der Haustiere, Vol. 4, Nos. 5-6, pp. 374-412; quoted by Schroeder, 25th Annual Rept. B. A. I., p. 136.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 652.

p. 225) as an important aid in recognising a type. Duval[1] says this test serves admirably.

RELATIONSHIP OF HUMAN AND BOVINE TYPES OF THE BACILLUS TUBERCULOSIS.

Raw[2] admits that "The methods by which the different bacilli can be differentiated are....not wholly satisfactory," while Schroeder[3] is satisfied that the various existing types of tubercle bacilli are simply mutation forms of one specific organism which gradually merge one into the other.[4]

While maintaining the difference in species between the parasites concerned respectively with the forms of tuberculosis occurring in cold-blooded species, in birds and in rats, and that all these are in no case identical with the parasites of human tuberculosis, Foulerton[5] admits that the more important question as to the identity of the parasites of human and bovine tuberculosis has not yet been settled.

Fibiger and Jensen[6] "....admit that the majority of cultures isolated from cattle possess the qualities regarded as peculiar to 'typus bovinus,' and also that the greater number of cultures isolated from human sputum can be placed in the 'typus humanus'; but there are some cultures remaining which are to be considered as transition forms, having some qualities common to the human, others to the bovine, type."

Delépine[7] is fully convinced of the unity of human and bovine tuberculosis—a unity, he adds, which does not preclude variations.

Dawson[8] says that "....the preponderance of evidence favours the view that all forms of tuberculosis, from that found in man, even to that found in cold-blooded animals, are identical. That the variant types of tubercle bacilli are the product of environment receives confirmation from our laboratory experiences with the pathogenic bacteria, which all workers know show variations in morphology, biological properties, and pathogenesis,[9] according to the medium, age of culture, passage through various animals, and other environmental influences of which we are probably now ignorant."

Professor Bang[10] adds: "Avian tuberculosis is considered to be very different from mammalian tuberculosis. Now, in my laboratory, I, with my son, have done some experiments with feeding animals with avian tuberculosis, and we have found that cultures of avian tubercle bacilli are able to produce a bad infection of tuberculosis. There is no doubt that bovine tuberculosis is not so different from human

1. Chas. W. Duval, M.D., Prof. of Pathology, Tulane University, New Orleans, 6th I. C. on T., Vol. 4, pt. 2, p. 729.
2. 6th I. C. on T., Vol. 1, pt. 2, p. 782.
3. 25th Annual Rept. B. A. I., p. 138.
4. B. A. I., Circular 153, p. 39.
5. The Veterinary News, March 26th, 1910, p. 168; for full reference, see p. 25.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 681.
7. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 218.
8. 6th I. C. on T., Vol. 4, pt. 2, p. 737.
9. "Pathogenesis"—The doctrine of the origin and development of disease.
10. 6th I. C. on T., Vol. 4, pt. 2, p. 610.

tuberculosis as is avian tuberculosis from mammalian tuberculosis. If avian tuberculosis is able to infect mammalia, we are obliged to think that the same would be the case with bovine tuberculosis."

In relation to the differences between human and bovine tubercular lesions, Dr. Pickett Turner[1] points out, rather ingeniously, that they are not so great as the differences between small-pox and vaccinia, which are known to be simply the human and bovine forms respectively of the same disease.

Dinwiddie[2] suggests that the course of consumption in humans, whether slow or rapid (galloping), may be the result of the degree of virulence of the bacillus concerned or the receptivity of the individual. The slow or non-progressive course of affections of tubercular adenitis, characteristic of scrofula, has been ascribed by writers to both deficiency in virulence and number of the bacilli present.[3]

At the British Congress on Tuberculosis, 1901, Professor John M'Fadyean, M.B., M.R.C.V.S.[4] (now Professor Sir John M'Fadyean, etc.), Principal of the Royal Veterinary College, London, stated that "It cannot be denied that what may be called bovine tubercle bacilli are, as a rule, distinctly more virulent for cattle and other domesticated animals than human bacilli, or that the results of experiments indicate that in natural circumstances there is little danger of cattle becoming infected from human beings. But it cannot be admitted that the low virulence of human bacilli for cattle proves, or even makes it probable, that bovine bacilli have only a feeble pathogenic power for man. That might have been held to be probable if it had been shown that bovine bacilli were very virulent only for cattle; but since it is well established that these bacilli are highly dangerous for such diverse species as the rabbit, horse, dog, pig, and sheep, and, in short, for almost every quadruped on which they have been tried, it appears to be highly probable that they are also dangerous to man. At any rate, it is impossible to cite any ascertained fact relating to other bacterial diseases that makes the contrary conclusion probable. It is well known that the majority of disease-exciting bacteria are harmful to only one or two species, but all those that are common to all the domesticated animals are also pathogenic to man."

The British Royal Commissioners[5] state: "We prefer to regard these two types as varieties of the same bacillus, and the lesions which they produce, whether in man or in other mammals, as manifestations of the same disease."

INTERTRANSMISSIBILITY OF HUMAN AND BOVINE TUBERCULOSIS.

Koch's famous disclaimer

When, in 1901, Koch stated that bovine and human tuberculosis were distinct diseases, and that man was only rarely infected

1. Tuberculosis: Its origin and extinction, p. 43.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 686.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 689.
4. Trans. B. C. on T., 1901, Vol. 1, p. 80.
5. Final Rept., p. 36.

by the bovine disease, a great responsibility seemed to be lifted from the shoulders of cowkeepers.

Dawson[1] says, " Already a large amount of work has been done which shows that tuberculosis is an intercommunicable disease. [2]From the nature of things we cannot, by experimental data,.... prove the communicability of animal tuberculosis to man, but sufficient evidence is at hand to convince us that man does contract tuberculosis by contact with and by the use of the edible products of tuberculous cattle." Professor Jensen,[3] of Copenhagen, admits that the possibility of the transmission of human tuberculosis to cattle by inoculation is now proved, and cites the review by Fibiger of the great number of experiments made to throw light on the question.

" In 61 series of experiments, 81 calves, heifers, cows, and oxen were inoculated with human tuberculosis ; in 41 experiments on 51 animals the result of the inoculation was positive. In many cases the inoculation caused only local processes extending to near-by glands, but the experimental animals were all killed comparatively early, so that the disease could well have spread farther if the animals had lived longer. As is known, tuberculosis of cattle frequently remains local for a long time. Sometimes the inoculations caused violent tuberculosis in the experimental calves, and this was particularly the case when the inoculation material came from patients affected with 'feeding tuberculosis' (Ravenel, Wolff, Fibiger and Jensen, Westenhoeffer)."

NATHAN RAW, M.D.
Physician, Mill Road Infirmary, Liverpool.

Raw[4] maintains that human and bovine tuberculosis must be considered as different varieties, and that tubercle bacilli of bovine type are able to set up numerous lesions in the human body as settled for all time. [5]Man is subject to both forms of the disease.

Bacilli of *typus humanus* produce :—

- Pulmonary tuberculosis.
- Tuberculous laryngitis.
- Secondary intestinal ulceration.

Bacilli of *typus bovinus* produce Tuberculosis of—

Mesenteric glands.	Meninges.
Peritoneum.	Skin (lupus).
Lymph glands.	Genito-urinary apparatus.
Bones and joints.	Middle ear.

- Acute miliary tuberculosis.
- Secondary pulmonary tuberculosis (bo-phthisis).[6]

1. 6th I. C. on T., Vol. 4, pt. 2, p. 737.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 739.
3. Milk Hygiene, p. 78.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 781.
5. 6th I. C. on T., Vol. 1, pt. 2, p. 783.
6. The Lancet, March 26th, 1910, p. 844.

Hughes[1] is very clear that "At present, sanitarians of North America are convinced that the preponderance of evidence points to the capability of the transmission of bovine tuberculosis to man."

British Royal Commission investigate

The British Royal Commission, consisting of—

Sir Michael Foster, K.C.B., M.D., F.R.S., Professor of Physiology, University of Cambridge,

German Sims Woodhead, M.D., Professor of Pathology, University of Cambridge,

Sidney Harris Cox Martin, M.D., F.R.S., Professor of Pathology, University College, London,

John McFadyean, Principal and Professor of Comparative Pathology and Bacteriology, Royal Veterinary College,

Rubert William Boyce, Professor of Pathology, Liverpool University,

investigated this matter very thoroughly, and, as a result of their experiments, no doubt can remain that bovine tuberculosis *is* communicable to man. Certain differences were found in the virulence of the various strains of the bacillus obtained from bovine and human sources, but on the broad issue of the reciprocal infectivity of the disease between bovines and man no doubt can remain.

When dealing with the tuberculous material which they had obtained from humans, for the purpose of injection into lower animals, the Commissioners[2] state—

"We are therefore led to a conclusion from which there seems to be no escape, not only that the tuberculosis which was present in each of the cases of Group I. (human tuberculosis) was identical in all its features with bovine tuberculosis, but also that the bacilli actually came from a bovine animal; the tuberculosis was bovine tuberculosis implanted in a human body."

Bovine tuberculosis IS communicable to man

[3] "There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man.

Consumption traced to tuberculous milk

"....A very considerable amount of disease and loss of life, especially among the young, must be attributed to the consumption of cow's milk containing tubercle bacilli. The presence of tubercle bacilli in cow's milk can be detected, though with some difficulty, if the proper means be adopted, and such milk ought never to be used as food. There is far less difficulty in recognising clinically that a cow is distinctly suffering from tuberculosis, in which case she may be yielding tuberculous milk. The milk coming from such a cow ought

1. 6th I. C. on T., Vol 4, pt. 2, p. 979.
2. Second Interim Rept., p. 28.
3. Second Interim Rept., p. 36.

not to form part of human food, and indeed ought not to be used as food at all.

"Our results clearly point to the necessity of measures more stringent than those at present enforced being taken to prevent the sale or the consumption of such milk."

More stringent measures urged

It has been a rather commonly accepted view that little risk was involved by tuberculosis in cows unless the udder was affected. The Royal Commissioners[1] do not accept this view, however. They point out that animals affected with pulmonary disease cough up large numbers of virulent bacilli, and they are either scattered about the shippon or swallowed, and so the intestinal canal becomes infected. Apart from this the fæces may be a grave source of infection, and they lay more stress upon this than upon pulmonary infection.

"We are thus brought face to face," says Dawson,[2] "with the fact that when a cow's lungs are sufficiently involved to cause her to discharge tubercle bacilli she becomes a disseminator of tuberculosis, regardless of the question of her udder being diseased. The fact that there is extreme care, as regards cleanliness, in milking operations about such animals is no guarantee that the milk is free from tubercle bacilli."

The evidence obtained by our Commissioners, as well as by the Imperial German Commission, whose findings agree uniformly with those of the British Commission, seems to point to the view that Koch was correct in believing bovine and human tuberculosis are not identical.

This is of little practical importance from our present point of view, seeing that both the diseases are reciprocally communicable and fatal.

It is easy to realise the importance of this when one so often sees a cow's flanks covered with cakes of dry dung an inch or so thick, and with how little compunction a few crumbs of these are shaken into the milk pail during milking, not to mention the danger of other cows in the same shippon being infected.

Newsholme[3] says that the "....view most generally and justifiably entertained is that human tuberculosis may be and is caused by bacilli of either the bovine or human type." He also quotes Ravenel's views:

"'Theoretically, there is no reason why the bovine bacillus should not be readily transmitted to man. It has, for all other mammalia on which it has been tried, a virulence greatly exceeding that of the human tubercle bacillus. It would certainly seem a remarkable anomaly for man, who is one of the most susceptible of all animals to tuberculosis, to be immune to the most powerful virus known. In the whole range of communicable diseases we have nothing comparable to this state of affairs, should we admit it.'"

1. Second Interim Rept., p. 28.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 736.
3. The Prevention of Tuberculosis, p. 130.

Bonney[1] reminds us "Smith declares that if either the human or the bovine bacillus were completely eradicated from the world, the other would continue to induce the disease."

Bang[2] sums up as follows :—

Possibility and probability

"It may, therefore, be said that the discussion has led to the conclusion that scientists agree that bovine tuberculosis can infect human beings, but that they disagree still as to the question of how frequently this occurs. I shall not here enter more closely into this question, which has been discussed at the Congress now ended. I shall merely state that I have always been of the opinion that man is chiefly infected through man, just as cattle are chiefly infected through cattle. Human and bovine tuberculosis are produced by the same bacillus, but the latter has adapted itself to the different soil by its growth through many generations in the body of man and cattle respectively, so that it is divided into two varieties, of which each has a higher virulence in the species of animals concerned. But to me there is no doubt that bovine tuberculosis more easily attacks man than human tuberculosis attacks cattle."

Possibility of transmission is only one of the factors

Delépine points out, however, that the possibility of transmission is only one factor in a consideration of the broad issue. He says that [3]"In studying the mode of spread of any infectious disease it is always necessary to keep in mind the complexity of the conditions influencing or determining the occurrence of infection. To the pathologist an infectious disease is invariably the result of the action of an invading or parasitic organism upon an invaded organism or host.

"The occurrence of a case of *tuberculosis vera* may be taken as absolute proof that Koch's bacillus has penetrated and multiplied in the tissues of an individual in whom it has caused the symptoms and lesions which we associate with tuberculosis. The converse is not true, and we cannot say that the presence of tubercle bacilli in a locality, or even within the body of an individual, is invariably followed by the production of tuberculosis. This sequence is probably the exception. The occurrence of cases of infectious disease is not determined only by the presence of the essential causal agent, but also by the co-operative agency of various factors, some of which become, under certain circumstances, so important that they more or less completely overshadow the essential cause. This is particularly noticeable in the case of diseases such as tuberculosis, which are caused by widely-distributed microbes. If, whenever the opportunity of infection occurred, the bacillus were abundant or virulent enough, and its possible victims were in a receptive state, there would be very few persons free from tuberculosis among civilised communities.

1. Dr. Sherman G. Bonney, Pulmonary Tuberculosis, p. 34, 1908. W. B. Saunders Company.
2. 6th I. C. on T., Special Vol., p. 217.
3. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 217.

"The importance of predisposing factors is often so great that not a few clinicians and administrators have given but scant attention to the essential cause.

". . . . We must, therefore, take account of the possible action of a great number of factors, which may be grouped into the following categories :— Other factors

"Distribution and habits of the infecting parasite.

"Conditions influencing the quantity of the parasite.

"Conditions influencing the virulence of the parasite.

"Opportunities and channels of infection.

"Conditions influencing the resistance of the possible host.

"Proportion and completeness of recoveries."

Schroeder[1] confirms these views. He says "We must bear in mind here that infection with tuberculosis does not always occur even after the germs of the disease have been introduced into the body with food or otherwise.

"Various incidents, it seems, must fall together with the presence of tubercle bacilli in the body before the disease develops. If this were not the case, the frequency with which dairy products contain live tubercle bacilli, and the wide distribution that the bacilli have in such products, would alone be sufficient to destroy the human race."

INSTANCES OF TUBERCULOUS INFECTION FROM BOVINES TO MAN.

Professor John M'Fadyean[2] points out that "The evidence in favour of the view that the ingestion of tuberculous milk is one of the causes of human tuberculosis includes a number of recorded cases in which the relationship of cause and effect appeared to be obvious. From the nature of the circumstances, evidence of this kind is very scanty, and it must be admitted that very few of the alleged examples are absolutely convincing. Tuberculosis is a disease that develops slowly, and, assuming for the moment that tubercle bacilli do occur in milk, and are a cause of disease in persons consuming such milk, it is obvious that, as a rule, the very act by which the infection is brought about destroys the only direct evidence of cause and effect that exists. Value of the evidence

"One could only expect to be able to trace the disease to the milk when, after the onset of symptoms pointing to infection by way of the mouth, the cow from which the milk had been obtained was still available for examination. In practice this is rarely the case, and it is, therefore, not surprising that medical literature contains very few specific instances of the infection of human beings with tuberculosis by means of milk. It is obvious, however, that the entire absence of evidence of this kind would in no way exonerate milk from the suspicion of being one of the causes of human tuberculosis.

1. 25th Annual Rept. B. A. I., p. 150.
2. Trans. B. C. on T., 1901, p. 82.

"We have already seen that, at least in this country, in a considerable number of cases of tuberculosis occurring in early life, the first seeds of the disease appear to have entered the body by way of the mouth. What proportion of these cases ought to be ascribed to tubercle-infected milk? It scarcely appears to be possible to give a very confident reply to this question, though some distinguished authorities have not hesitated to express the opinion that practically all the cases of primary intestinal tuberculosis occurring in childhood may be set down to this cause."

Professor Jesse E. Pope,[1] East Orange, N.J., tells of the following case, furnished him by a physician of high standing:—

Infection from milk

"In the spring of 1900 a farmer, of Adair county, Iowa, shipped in a car load of young feeders from New York State. These cattle were separated from his herd by a barbed wire fence. Some months later the farmer's 14-year-old daughter was taken ill with miliary tuberculosis. On investigation it was discovered that she had been drinking milk from cows which were suffering from tubercular diarrhœa, and some of which died later with acute tuberculosis. The farmer lost two-thirds of the cattle shipped in, and his home herd was practically ruined by infection; yet he lost his suit for damages against the man who had sold him the infected cattle."

Dawson[2] cites the following cases, recorded by Salmon in Bulletin No. 33 of the Bureau of Animal Industry, U.S.A., and maintains that they "....show clearly the danger from this source confronting the human race.

"THREE CASES OF SKIN TUBERCULOSIS DUE TO ACCIDENTAL INOCULATION WITH THE BOVINE BACILLUS.

Wound infections

"Veterinarian Moses wounded his thumb while making an autopsy on a tuberculous cow. The wound healed, but at the end of six months a cutaneous tubercle had formed, and the patient died of phthisis in 18 months.

"A man engaged in cleaning a cattle car was wounded upon the back of the hand by a piece of the broken woodwork of the car. Tuberculosis developed at the wounded surface, and was treated by a physician. The patient's health declined, and he died of generalised tuberculosis within a year.

Cream infection

"A physician was called to treat a six-year-old girl for supposed ivy poisoning. Fresh cream had been applied to the affected parts at home. Tuberculous ulcers developed where the cream had been used topically. Two rabbits, inoculated with some milk from the same cow, developed tuberculosis. Likewise a rabbit, inoculated intraperitoneally with caseous material from the girl's leg, developed fatal tuberculosis.

"A similar case was where a girl, who had a wound on the finger,

1. 6th I. C. on T., Vol. 4, pt. 2, p. 578.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 739

became infected by milking a tuberculous cow. Within six months more than sixty subcutaneous abscesses developed in various parts of the body. The nature of these lesions was determined by the inoculation of a rabbit. **Wound infections**

"A sailor tried to remove tattoos from his arm by pricking milk into the marks with a needle. Lupus developed, and the man made a recovery after surgical measures were taken.

"These cases show, as plainly as an experiment well could, that bovine tuberculosis can be communicated to man in a fatal form by subcutaneous inoculation.

"That bovine tuberculosis is communicated to man by the ingestion of the products of tuberculous cattle is just as plainly shown by the following cases, also cited by Salmon :—

"Twelve girls at a boarding-school contracted tuberculosis, and five of them died of the intestinal form of the disease. An examination of the cow which furnished the school with milk revealed extensive tuberculosis of the intestines and udder.[1] **Milk infections**

[2]"The daughter of a physician was accustomed to visit her father's farm on Sundays, and while there to drink freely of milk. She became ill and died in ten months. A *post-mortem* examination revealed tuberculosis of the abdominal viscera and mesenteric glands. On examination of the herd, four of the five cows comprising it were found tuberculous, two having disease of the udder.

"A child, twenty months old, died from abdominal tuberculosis three months after having visited its uncle's farm, where it was fed with milk from the family cow. The child's sickness began a few weeks after its return home. It had previously been in perfect health, as were also its parents. When the cow was examined she was found to have generalised tuberculosis.

"Two young daughters of a healthy family were raised on milk from a tuberculous herd, and both contracted tuberculosis, while two older brothers, who used little or no milk, remained well.

"A previously healthy man was treated for six weeks for supposed typhoid fever. As the expected convalescence did not occur, a consultation was had, and a diagnosis of acute miliary tuberculosis was made. Shortly after, the man's one-year-old child came down with meningitis of supposed tubercular origin, no *post-mortem* being permitted. Both parent and child had drunk largely of milk from a cow which a subsequent test and examination showed had extensive tuberculosis of the lungs, peritoneum, and udder.

"These cases could be extended in number, but are sufficient to show, beyond a reasonable doubt, that the disease can be communicated

1. In discussing this case, Wilcox says (Ostertag's Handbook of Meat Inspection, 1902, p. 632 footnote), Koch has recently stated that Ollivier subsequently corrected his report, and asserted the girls did not receive the milk of the tuberculous cow.
2. This is probably the case of Miss Gosse, of Geneva, described in interesting detail by Nocard (The Animal Tuberculoses, p. 84).

from cattle to man through the use of the products of tuberculous cattle and by subcutaneous inoculation."

Jensen[1] cites a few cases, some of which are identical with those given above, and mentions that Leonhardt, Sonntag, Hermsdorff, Klebs, Rotch, Lydtin and Stang, Johne, and many others have reported quite similar observations. "Of particular interest," says Jensen, "are the cases reported by Ravenel, Fibiger and Jensen, and many others of tuberculosis of children with prominent lesions in the digestive canal, while the tubercle bacilli present were so virulent for cattle that the origin of the cases in question were referred, with the greatest probability, to infection through the milk."

Significance of wound infections

Bruno Heymann[2] considers cases of accidental inoculation upon veterinarians and butchers of no importance. Compared with the frequency of opportunities for infection, they are very rare.

Newsholme[3] agrees that "....the development of fatal tuberculosis after such accidents is excessively rare."

The British Royal Commissioners[4] consider that although such cases have been carefully investigated they could not be accepted as unequivocally positive in character.

WHY IS TUBERCULOSIS NOT MORE RIFE AMONG PEOPLE WHO HANDLE MILK?

[5]"The apparent immunity of country children from bovine infection may be partially due to the fact that country mothers usually nurse their children, and to the further fact that country people, as a class, are not large consumers of raw milk."

Schroeder[6] confirms this view with regard to dairy employees. He says "They see too much milk, and they see how it is prepared."

[7]"Demographic statistics have shown that there are more deaths from tuberculosis in cities than in rural districts, and that it is essentially a disease of people who live indoors." In this we meet with a vastly more important factor in the problem of human tuberculosis than milk drinking.

AVIAN TUBERCULOSIS.[8]

Tuberculosis in birds, fowls, poultry, etc., appears to have some significance in relation to bovines; moreover, Rabinowitsch[9] isolated

1. Milk Hygiene, p. 79.
2. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.
3. The Prevention of Tuberculosis, p. 139.
4. Final Rept., p. 36.
5. Prof. Jesse E. Pope, 6th I. C. on T., Vol. 4, pt. 2, p. 572 footnote.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 611.
7. Maurice Fishberg, M.D., Physician to the United Hebrew Charities, New York, 6th I. C. on T., Vol. 3, p. 423.
8. We cannot deal seriously with Dr. Pickett Turner's "sporting guess" that avian tuberculosis is really actinomycosis. The doctor admits he has not even seen the avian bacillus under the microscope. See Tuberculosis: Its origin and extinction, p. 79.
9. Virchow's Archiv, 1907, cxc., p. 246.

avian tubercle bacilli from two cases of tuberculosis in man. The avian bacillus can grow at a temperature of 111° Fah., while the mammalian forms cease to propagate above 106° Fah. Apparently the bacillus has adapted itself to that of the bird species, whose body temperature is, as a rule, higher than that of mammals. "Nocard has been able to transform the bacillus of human origin," says Wladimiroff,[1] "by artificial means, into a bacillus presenting all the characteristics of the avian type. Still more striking is the adaptation shown by the tubercle bacillus of cold-blooded animals (snakes and fish), for such a microbe will grow at a temperature of 50° Fah. to 86° Fah., and has completely lost the power of infecting warm-blooded animals."

Tuberculosis of cold-blooded animals

"The avian type," according to the British Royal Commissioners,[2] "differs from the other two types in forming a slimy, whitish growth which is easily emulsified, and it maintains these characters after repeated subculture." The Commissioners[3] do not consider the evidence they have collected warrants their considering the avian bacillus identical with the bovine or human bacillus.

The United States Bureau of Animal Industry have drawn attention to avian tuberculosis as a cause of considerable loss through disease. They have found centres of infection at widely separated points—on the Pacific Coast, along the Hudson River, and at intermediate points. [4]"In all of the flocks attacked and examined it has been noted that the spread of the disease among the birds has been very rapid, and so virulent that the infection proved that only a few of the individuals in a flock escape after the infection has become established. The disease is spread readily from bird to bird by way of the digestive tract; and from the well-known habit of fowls picking their food out of dirt, and even from manure piles, it is evident that the infection will be quickly taken up by the healthy members of the flock." [5]"The importance of continued investigation in this direction is shown by the fact that numerous vague diagnoses, under the title of liver disease, spotted liver, 'going light,' rheumatism, etc., are common among poultry raisers, some of which....have been proved to be tuberculosis, thus suggesting that avian tuberculosis is rapidly becoming disseminated. The finding by all investigators of multitudes of tubercle bacilli in the fæces suggests the ease with which the disease may be spread throughout the flock. And it must be admitted, in the present state of our knowledge of this disease in mammals and birds, that the appearance of tuberculosis in a flock of chickens or other poultry opens up for that locality all the questions connected with this malady."

Significance

Mohler and Washburn consider their findings indicate the probability of the disease being much more extensive in its depredations

1. See Wladimiroff, 6th I. C. on T., Special Vol., p. 138.
2. Final Rept., p. 30.
3. Final Rept., p. 36.
4. Mohler, 25th Annual Rept. B. A. I., p. 160.
5. Mohler and Washburn, 25th Annual Rept. B. A. I., p. 165.

than has hitherto been realised. Hereunder we continue with an abstract of their paper quoted below.

Probably the most extensive article resulting from the investigations on the relation existing between avian and mammalian tubercle is, according to the above-named authors,[1] the report of Weber and Bofinger, of the Imperial Health Office, of Germany, which appeared in 1904. These writers are very positive that fowls cannot possibly be infected by mammalian tubercle bacilli, no matter how applied.

"They are equally positive that no transformation ever occurs, either of avian tubercle bacilli during a stay in the body of a mammal, or of mammalian tubercle bacilli when supported by the tissues of a bird.

"A report by Rabinowitsch, also issued in 1904, in which are recorded the findings of autopsies made upon 55 birds from the Berlin Zoological Gardens, and the conclusions derived from careful study of cultures obtained from them, furnishes most valuable information regarding the relations of avian with mammalian tubercle bacilli. In two cases tubercle bacilli of the mammalian type were recovered from fish-hawks. As other birds of the same species were found to be infected with avian tubercle bacilli, it seems justifiable to class fish-hawks with parrots, in the sense that both of these species of birds are susceptible to infection by either type of tubercle bacilli.

"Rabinowitsch also succeeded in producing tuberculous lesions in two hens through feeding them with pure cultures of tubercle bacilli of human origin, but owing to the fact that no cultures were recovered from the bodies of the fowls afterwards, some investigators are inclined to dispute the success of the experiment.

"Important variations in the virulence of the various avian cultures were noted, a fact which has been fully substantiated by the work of Mohler and Washburn, and a condition which is quite in conformity with the variations found in cultures of other bacteria.

Rats and mice carry infection

"By extending her investigations, a number of rats and mice that were caught in the birds' quarters of the Berlin Gardens were found, by Rabinowitsch, in several instances to have contracted tuberculosis. Conversely, it was learned that the birds would eat the affected carcasses of the rats and mice and contract tuberculosis by that means, and in this manner the rodents served to spread the infection materially.

Olaf Bang's experiments

"In 1908 Dr. Olaf Bang reported the results of a number of tests made for the purpose of determining the susceptibility of birds for mammalian tubercle bacilli, and also the extent to which mammals could be infected with tubercle bacilli of the avian type. He tested eighteen mammalian cultures carefully in regard to their pathogenicity for fowls, and found twelve that were capable of causing tuberculous

1. Mohler and Washburn, 25th Annual Rept. B. A. I., p. 171.

lesions in hens, while six were harmless by any of the means commonly used for inoculation.

"The results obtained in attempts to infect mammals by using avian tubercle bacilli were also successful in proving that young kids, calves, and foals possess considerable susceptibility for these organisms. He also found that continued retention of mammalian tubercle bacilli in the tissues of birds altered their pathogenicity for guinea-pigs, as they gradually became less virulent for these animals."

Increase in pathogenicity

Mohler and Washburn, in 1906, "....reported the successful inoculation of guinea-pigs, rabbits, and a cat with avian tubercle bacilli, and also noted a profound alteration in the pathogenicity and cultural characteristics of the culture used, until at last it would cause well-defined tubercular necroses within the viscera of the guinea-pigs, instead of merely a general congestion of the visceral organs, as was the case at first. Instead of spreading uniformly over the surface of the serum in a moist white layer, as at the beginning of the experiment, the recovered cultures appeared to increase in growths of small whitish clumps, somewhat similar to the manner of growth common to tubercle bacilli of the human type, except that the clumps were slightly flatter.

"Since the publication of the experiments just mentioned some criticism of the culture which was used in the tests has been noted. The objection has been made that the avian culture used in the experiments was not examined to see if it was pathogenic for fowls. The writers made the statement that this culture 'is well known to bacteriologists, and is accepted by most of them as meeting all the requirements of tubercle bacilli of the avian type.' This statement obviously includes its pathogenicity for fowls, and this fact was fully proven by the inoculation of chickens, which resulted in the production of well-marked lesions of tuberculosis, one of the birds inoculated developing a very typical tuberculous tumour upon one of its joints, in addition to the lesions of the abdominal viscera."

In confirmation of the eminent investigators Lydia Rabinowitsch and Bang, and in opposition to Weber and Bofinger, Mohler and Washburn[1] prove that "....the micro-organisms of naturally acquired tuberculosis in fowls can be made to lodge and multiply within the tissues of swine, cats, rabbits, and guinea-pigs. They will cause progressive wasting and death in guinea-pigs without producing characteristic necrotic foci in the organs, although recourse to the microscope reveals the presence of vast numbers of tubercle bacilli in the lungs, spleen, liver, or kidneys.

"Repeated passage of such avian tubercle bacilli in large numbers, from animal to animal, will result in the final development of a type of tubercle bacilli which will produce typical lesions of tuberculosis in mammals.

1. 25th Annual Rept. B. A. I., p. 175.

"The carcasses of tuberculous fowls should never be fed to swine, as the latter may contract tuberculosis from such food."

Oregon outbreak

An important and interesting outbreak of avian tuberculosis in Oregon was investigated by the Bureau of Animal Industry. This outbreak seemed to be extending to the swine of the same farm, causing many of them to be condemned as tuberculous when inspected at the abattoir.

The B. A. I. inspector stationed in Oregon reported:

[1]"The history of this infection is somewhat interesting. About one year ago Mr. B. had 65 grown chickens; one or two of them were noticed to be sick, and after a lingering illness died. About three months later other members of the flock became affected, and died in the same manner. Altogether about 30 of the 65 died during the last six months, several of which were examined by the owner and found to be in the same condition as those which we examined. He now has remaining less than 20 of his original flock, and most of them are affected with the disease. These chickens are in the yard with about 30 hogs, and those that have died have been consumed by the hogs. He has slaughtered some of the hogs lately and has found their livers affected exactly similarly to those of the chickens.

"The facts shown in this letter, and reports from a neighbouring abattoir which confirmed the presence of tuberculosis in the swine, made further investigation desirable, especially as there was nothing in the history of the outbreak among the hogs to indicate that they derived their infection from tuberculous cattle or their products. Several fowls were, therefore, secured and shipped to the laboratory at Washington. The following letter accompanied them:

"'The four hens forwarded were secured from the ranch of Mr. B., referred to in my previous letter. These are all the chickens that he has left. On my earlier visit to this ranch I found hens that presented no physical symptoms whatever, and yet they showed, on *post-mortem*, the advanced lesions of tuberculosis. Mr. B.'s turkeys all died of tuberculosis. The turkey that is included in this shipment was secured from an adjoining ranch owned by Mr. R. Mr. R.'s chickens mix with the chickens of Mr. B., and a great many of them were tubercular, and have been killed. His turkeys had all died except the one which I am forwarding.'"

At the Sixth International Congress on Tuberculosis, Mohler and Washburn[2] stated "Investigations are now in progress whose purpose is the tracing, if possible, of the infection of the hogs to the eating of tuberculous fowls, or the infection of the fowls to the ingestion of tuberculous hogs, or, what would prove to be more valuable still, to trace the infection of both birds and hogs to some common source as yet unknown. It is of interest to note that three daughters of

1. 25th Annual Rept. B. A. I., p. 166.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 625.

the proprietor of this ranch have died of tuberculosis, and that a son is now in the last stages of the disease."

Their investigations resulted in demonstrating the connection between avian and porcine tuberculosis, leaving no room for reasonable doubt [1]"....that the condemned tuberculous hogs from the Oregon ranch owed their infection to the ingestion of the carcasses of the affected hens, just as the two hogs, in the test at the laboratory, contracted their infection unquestionably through feeding upon ....birds," and proving "....that danger to mammals may exist wherever tuberculous birds are present."

The authors conclude that [2]"....any preventive methods for controlling tuberculosis must take into consideration all species of animals that are susceptible to this infection."

Tuberculous eggs

It is of some interest to note that one of the hens which had been transported from the Oregon ranch to the Washington Laboratory laid a perfectly formed egg on January 6th, and another diminutive egg, not quite normal in appearance, on March 24th. Injection of the white of these eggs into guinea-pigs caused tuberculosis in the animals.

C. J. Reakes, M.R.C.V.S.,[3] Director of the Live Stock and Meat Division, New Zealand, considers "It is highly desirable that poultry should be scheduled as 'animals' within the meaning of the Stock Act."

The British Royal Commission,[4] however, find that "The calf, pig, monkey, guinea-pig, horse, cat, and rat behave alike to the avian bacillus, which in them never produces a progressive tuberculosis, though it sometimes multiplies in the body and becomes disseminated in the tissues and may kill if a large dose is given intravenously..... The chimpanzee, in the single experiment performed, was found to resist a large dose (50 milligrammes of culture) of the bacillus injected subcutaneously and no tuberculous lesion was found when the animal died three years afterwards. In the dog, large doses injected intravenously produce no effects."

[5]"The rabbit and mouse are the only two mammals in which the avian tubercle bacillus causes progressive tuberculosis."

[6]"....Mammals generally, with the exception of the rabbit and mouse, and, perhaps to a less extent, the pig and goat, would appear almost absolutely resistant to it.

[7]"We must conclude, as the result of our investigations, that the unmodified avian tubercle bacillus is a negligible factor in the production of human tuberculosis."

Dr. Corner, a well-known Harley Street physician, has established a school of light agriculture on a grass farm of some 150 acres at

1. 25th Annual Rept. B. A. I., p. 168.
2. 25th Annual Rept. B. A. I., p. 176.
3. Annual Rept. New Zealand Dept. of Agri., Commerce and Tourists, 1910, p. 28.
4. Final Report, p. 8.
5. Final Report, p. 7.
6. Final Report, p. 37.
7. Final Report, p. 38.

Southgate. The work includes poultry breeding. During a visit of the members of the Dairy Students' Union, Dr. Corner[1] stated that 23 per cent. of chickens die of tuberculosis. For this reason, he does not now permit his fowls to run on the meadows, believing, as he does, that there is an association between tuberculosis in fowls and in cattle; indeed, he states that it has been shown that the disease can be transmitted from fowls to bovines.

Prevalence in Orkneys

The Dairy, for June 15th, 1911 (p. 162), reports that "The newspapers of Northern Scotland report an extraordinary epidemic of tuberculosis among poultry throughout the Orkneys, and extensive losses are being experienced among the crofters and small holders of these far northern districts. It is well known that, as in the western isles, human tuberculosis prevails to a deplorable extent among the Orcadians. This is, no doubt, largely due to faulty hygienic conditions in regard to housing—as well as to climate—and one can imagine that if the housing conditions of the people are not what they ought to be, the conditions under which the live stock is reared and kept may also show room for improvement. The extent to which tuberculosis prevails among the cattle stock of Orkney came under the notice of the Departmental Committee which took evidence last year regarding the work of the Congested Districts Commissioners. One witness gave it as his opinion that half the byres in Orkney were infected with this disease, and deaths among stock were frequent. A further statement by a farmer was that he had lost four cows in one year from what he believed to be tuberculosis, so that the condition of matters so far as this is concerned is a matter of serious concern. What connection there may be, if any, between the prevalence of human tuberculosis and tuberculosis among the domestic animals of Orkney is a matter for the experts to determine, but it is certainly suggestive that a great proportion of the poultry population of the Orkneys is affected with tuberculosis with a consequent considerable mortality. It is, of course, a well-established fact that tuberculosis among domestic fowls is not peculiar to these islands alone. Those who have experience in poultry-rearing know that fowls are quite susceptible to the development of tuberculosis almost anywhere if due regard is not paid to the conditions under which they are kept, and the abnormal extent to which the disease prevails in Orkney would point to a lack of sufficient attention in regard to housing and the need for strenuous measures being adopted in order that the serious avian mortality of these districts may be checked. It is understood that steps in that direction are being taken by the Congested Districts Board, and that some interesting investigations are likely to be instituted in regard to the matter."

Further information on avian tuberculosis will be found in Appendix E., p. 449.

1. See Farm and Home, July 16th, 1910, p. 516.

PREVALENCE OF TUBERCULOUS MILK.

Delépine[1] defines *the possible sources of tubercle bacilli* in cow's milk as follows :— Sources of infection

"THE SECRETIONS OR DEJECTA OF THE TUBERCULOUS COW PRODUCING THE MILK, OR OF COWS KEPT IN THE SAME SHED.

"(1) The muco-purulent *discharges from the respiratory passages*, especially in cases of advanced tuberculosis of the lungs and respiratory passages.

"(2) The *alvine discharges* where there is disease of the intestinal tract, or passage of tuberculous discharges from the respiratory passages into the esophagus. The dung becomes a serious source of infection when tuberculosis of the intestine causes severe diarrhœa, as it frequently does in the latter stages of the disease.

"(3) The *urine*, more specially when there is advanced tuberculosis of the kidneys and urinary passages.

"(4) *Utero-vaginal discharges* in cases of tuberculosis of the genital organs.

"(5) The *milk* in cases of tuberculosis of the udder, and, possibly, sometimes in cases of advanced tuberculosis without apparent tuberculosis of the udder.

"Of these products *tuberculous milk is an unavoidable source of tubercle bacilli*.

"The *intestinal and genito-urinary discharges* may *pass directly* into the milk pail at the time of milking, when that operation is conducted negligently, or *indirectly* by first coating the skin covering the udder, the flanks, thighs, and tail of the cow ; this, however, should not occur when the cow is properly kept and groomed, the milking conducted carefully, and the milk received in proper milk pails.

"The discharges from the *respiratory and upper alimentary passages* may also at times pass indirectly into the milk by contaminating the cow and various articles in the stable. All these discharges retain their virulence after drying, and may be blown about in the shape of *dust* and infect the cow, the cowman, or any vessel kept in the stable. The milk may also be contaminated with bacteria, including tubercle bacilli, through the intermediation of flies. Fly contamination.

"THE COWMAN AND OTHER DAIRY HANDS.

"(1) It has been supposed by some that *direct and dangerous tuberculous infection* of the milk is frequently caused by tuberculous dairymen, either at the farm or elsewhere. It is obvious that tuberculous men of extremely dirty habits might, at times, lubricate their hands with their own expectoration before milking the cows, or contaminate the milk in other ways.

1. 38th Annual Rept. L. G. B., 1908-9, Suppl., p. 351.

"(2) The expectoration and other discharges from a tuberculous man may also contaminate the stable or his own clothing in the same way as the discharges from a tuberculous cow would, and thus cause *indirect contamination* of the milk.

"*Various farm animals other than the cow* may be a source of *indirect contamination* of the milk. *Swine* are most liable to tuberculosis, but *horses, dogs,* and *cats* should not be ignored as possible, though rare, sources of tubercle bacilli. Various poultry birds are also very liable to the disease, i.e. *turkeys, geese, ducks, hens,* etc.

"The *dairy vessels* may become infected, not only when kept in the stable, but when handled by dirty or tuberculous dairy hands, or 'cleaned' with water highly polluted with the drainage of infected stables.

"Of all these sources of infection some are *unavoidable, constant, and generally massive,* others are *avoidable, accidental, and are generally slight.*"

Jensen[1] gives a table essentially after Klimmer, showing percentages of tuberculous milk in various cities and towns. He regards the figures as, to a great degree, authentic.

City.	Number of Samples Examined.	Number of Samples in which Tubercle Bacilli were found.	Examination made by
Copenhagen	28	4	St. Friis.
Copenhagen	33	0	St. Friis.
Berlin	40	3	Obermuller.
Berlin	13	8	Obermuller
Berlin	64	9	Petri.
Halle	9	2	Buege.
Genoa	33	3	Massone.
Schwäbisch-Gmund ..	43	5	Ott.
Schwäbisch-Gmund ..	28	3	Ott.
Milan	54	4	Fiorentini.
St. Petersburg	71	4	Sacharbekoff.
Dorpat	40	1	Kudinow.
Krakau	60	2	Bujwid.
Wilna	22	12	Nonewitsch.
Helsingfors	21	8	v. Hellens.
Paris	30	6	Girard.
Liverpool	144	3	Boyce, Woodhead,
Liverpool	24	7	and others.
Liverpool	55	3	Delépine.
Liverpool	125	22	Delépine.
Liverpool	159	12	Boyce.
Liverpool	91	16	Boyce.
London	100	7	Klein.

1. Milk Hygiene, pp. 74-5.

To the preceding table we may add the following :—

City.	Number of Samples Examined.	Number of Samples in which Tubercle Bacilli were found.	Per-centage.	Examination made by
Leipzig ..	210	22	10·47	Eber.[1]
London ..	—	—	10·80	Murphy.[2]
District of Columbia ..	73	2	2·70	Mohler.[3]
Washington, D.C. ..	numerous	—	5·50	Schroeder.[4]
Seven American Cities ..	223	15	6·72	Anderson.[5]
Manchester ..	5,360	450	8·30	Delépine.[6]
Paris	—	—	12·00	Magill.[7]
New York City, 1901.. ..	—	—	10·50	Magill.[8]
Washington, D.C. ..	223	15	6·72	Anderson.[9]
New York City, 1907-8 ..	107	17	16·00	Hess.[10]
London ..	77	17	22·00	M'Fadyean.[11]
Berlin	25	7	28·00	Rabinowitsch and Kempner.[12]

In the above table it will be noticed that Hess's figure for New York milk is much higher than that given by Anderson. Hess believed this to be due to his more searching method of detection. In the first place, Anderson did not inject the cream (which is known to entangle, while rising, a considerable proportion of the bacteria present). Hess points out that had he omitted to inject the cream, his figure would have been reduced from 16 per cent. to 13 per cent.

Moreover, Anderson inoculated one animal only with each sample. Hess injected two animals with each sample, and points out that out of 19 tuberculous specimens, only nine produced tuberculosis in both animals.

1. Translation published July, 1908, as a pamphlet in the interest of the pure milk movement, by J. Willman, Shelton, Conn. See 25th Annual Rept. B. A. I., p. 150.
2. Reported by Sir Shirley Murphy. Private communication, Dec. 23rd, 1909.
3. B. A. I., Circular 153, p. 32.
4. B. A. I., Circular 153, p. 41.
5. P. H. and M. H. S., Bull. No. 56, p. 196.
6. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 222.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 531.
8. 6th I. C. on T., Vol. 4, pt. 2, p. 531.
9. P. H. and M. H. S., Bull. 41, p. 191.
10. 6th I. C. on T., Vol. 4, pt. 2, p. 525.
11. The Lancet, Vol. 2, 1899.
12. Zeit. f. Hyg., Bd. 31, 1899, p. 137; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 176.

Park[1] considers that " From 5 to 20 per cent. of the market milk of the largest cities is infected." Mohler[2] refers to the "…. investigators who have studied market milk, and found from 2·7 to 55 per cent. of the samples examined to contain tubercle bacilli."

Delépine[3] shows that " The milk of 28·3 per cent. of all the cows supplying milk to Manchester has….*at one time or another* contained enough tubercle bacilli to produce tuberculosis in experimental animals. This figure is obviously not applicable to any single year." The period referred to is 1896 to 1908 inclusive.

By a similar mode of reckoning Eber[4] showed that in Leipzig "….among 70 dealers, nineteen, or 27·1 per cent., were more or less intermittently selling infected milk."

Expressed on the number of farms, Delépine[5] found that 344 out of 1,613, that is, 21·3 per cent., around Manchester have, at one time or another during 13 years (1896-1909), been found to produce tuberculous milk.

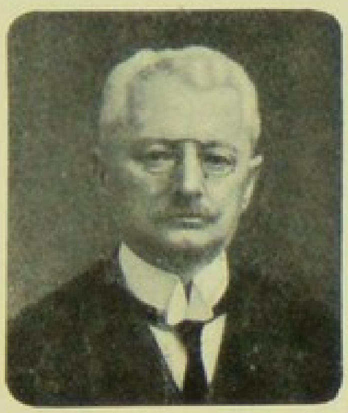
The Secretary of Agriculture,[6] United States, reported that " The examination of sediment taken from cream separators of public creameries throughout the country has demonstrated the presence of tubercle bacilli in about one-fourth of the samples."

Newsholme[7] points out that the experience of the East Prussian Herdbook Society must be regarded as exceptional. (The milk of 1,499 herds out of 1,596 herds was found free from tubercle bacilli.)

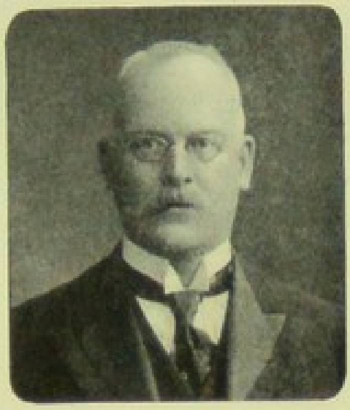
After reviewing some English and Continental figures, he concludes that "….it would appear that about 20 per cent. of the mixed milk supplied to towns contains living tubercle bacilli."

1. Wm. H. Park, M.D., New York, 6th I. C. on T., Vol. 1, pt. 1, p. 160.
2. B. A. I., Circular 153, p. 30.
3. 38th Annual Rept. L. G. B., Suppl., p. 388.
4. 25th Annual Rept. B. A. I., p. 150.
5. Pro. Roy. Soc. Med., Vol. 3, No. 7, Epidemiological Sect., p. 228, May, 1910.
6. Annual Rept. of the Secretary of Agriculture, Washington, D.C., 1907, p. 30; quoted by Schroeder, 25th Ann. Rept. B. A. I., p. 151.
7. The Prevention of Tuberculosis, p. 144.

FOUR OF THE VETERINARY PROFESSORS OF THE UNITED KINGDOM.



THE LATE W. O. WILLIAMS, F.R.C.V.S., F.R.S.E.
Professor of Veterinary Medicine, Liverpool University.



PRINCIPAL A. E. METTAM, B.Sc., M.R.C.V.S., M.R.I.A.
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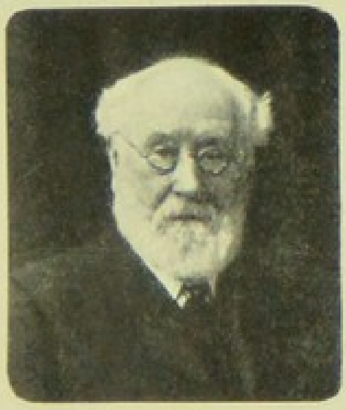


PRINCIPAL JAMES McCALL, F.R.C.V.S.
Professor of Veterinary Medicine, The Veterinary College, Glasgow.

O. CHARNOCK BRADLEY, M.D., D.Sc., M.R.C.V.S.
Principal and Professor of Anatomy Royal (Dick) Veterinary College, Edinburgh.

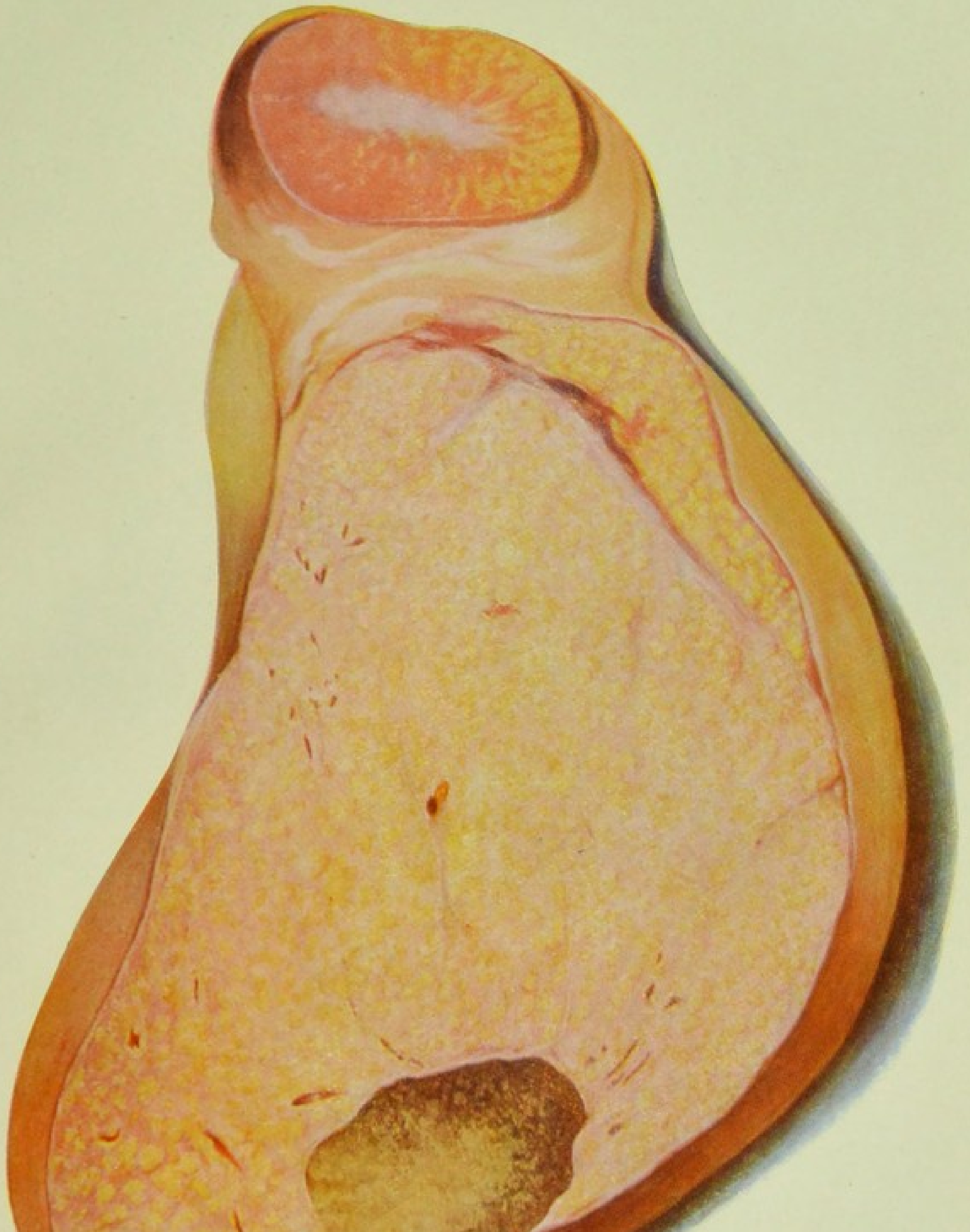
[We deeply regret to record that since the above portraits were arranged for publication, Professor W. O. Williams has passed away. At the time of writing, his veterinary school are still mourning his loss.]

PORTIONS OF TUBERCULOUS LUNGS FROM CATTLE.

Reproduced from Bull. No. 38, B. A. I. By kind permission of Dr. A. D. Melvin. PLATE V.

TUBERCULOUS LIVER OF COW.

Reproduced from Bull. No. 38, B. A. I. By kind permission of Dr. A. D. Melvin. PLATE VI.



TUBERCULOUS UDDER OF COW.

TUBERCULOUS OVARY OF COW.

LUNGS OF A HEALTHY HOG.

TUBERCULOUS LUNGS OF HOG.

Reproduced from Bull, No. 38, B. A. I. By kind permission of Dr. A. D. Melvin. PLATE X.

TUBERCULOUS SPLEEN OF HOG.

SPLEEN OF HEALTHY HOG.

Reproduced from Veterinary Medicine.
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PLATE XI.

TUBERCULOSIS OF OUTSIDE OF LUNG. ("GRAPES.")

CHAPTER III.

BOVINE TUBERCULOSIS.

SYMPTOMS AND DETECTION OF BOVINE AND PORCINE TUBERCULOSIS.

THE following description is compiled from the writings of Drs. D. E. Salmon[1] and E. C. Schroeder.[2]

Schroeder[3] points out that "Tuberculosis is more effectually concealed in the bodies of cattle than in those of persons; and we all know how long a diagnosis with persons may remain in doubt.

"Perception, or the faculty of receiving impressions, is keenest where the nervous system has the highest development. Persons, though their perception of pain is much keener than that of lower animals, complain little during their earlier stages of tuberculosis, because, we may assume, they experience little pain or distress. Cattle, with their lower perception and comparatively insignificant means to express suffering, do not complain at all because of the pain and distress tuberculosis causes them."

"The detection of tuberculosis in any other way than by the tuberculin test," says Salmon,[4] "is often difficult or impossible during the life of the animal."

[5]"In the great majority of cases of tuberculosis in animals the symptoms are slight and not at all clear in their indications. As the functions of the body must be disturbed, more or less, before any symptoms are apparent, it is plain that in the earlier stages of the disease there are no symptoms, and that when symptoms develop the disease is already considerably advanced. It is only when the affected part is located where it may be easily examined that symptoms are shown by which the infection may be detected at a comparatively early stage."

[6]"In the case of a herd of cattle we have three sources of information—the symptoms brought out by a physical examination of each of the individual animals, the tuberculin test, and the examination of the carcasses of such animals from the herd as die of disease or are slaughtered. Each of these sources of information is of great value, and none of them should be neglected in case there is any reason to suspect the existence of the disease."

1. B. A. I., Bull. No. 38, p. 21; also Bull. 38, p. 41.
2. P. H. and M. H. S., Bull. 56, p. 531.
3. P. H. and M. H. S., Bull. 56, p. 531.
4. D. E. Salmon, B. A. I., Bull. No. 38, p. 41.
5. D. E. Salmon, B. A. I., Bull. No. 38, p. 21.
6. D. E. Salmon, B. A. I., Bull. No. 38, p. 41.

"PHYSICAL EXAMINATION."

Accessible Lesions.—[1]"....when the udder or the glands of the neck are the seat of tuberculosis the existence of the trouble is more likely to be revealed than when the affected organ is within one of the body cavities.

Cough "If the larynx, the air tubes, or the lungs are affected there is a short cough, which is heard particularly in the morning, at feeding time, or when the animal is let out of the stable in the cold air, or after it has been drinking cold water, and especially after violent exertion. This cough generally becomes more prolonged and convulsive as the disease advances.

Uterus "In case the uterus or ovaries are affected there may be abortion or sterility with abnormal sexual manifestations. If the intestines are affected there may be irregular attacks of diarrhœa. If a joint is diseased it is revealed by lameness.

"As the disease progresses the general health of the animal and the functions of nutrition are affected. Animals which have been in good flesh and laying on fat fail to profit by their food and begin to lose flesh."

In most animals there is high temperature, progressive emaciation, and loss of strength until death results. With some cases the general nutrition of the body remains unaffected, and these symptoms of the final stages of the disease are postponed until after the lungs or other vital organs have been almost completely filled with tubercular deposit. But if the disease continues to make progress, there must come a time when the nutrition and vigour fail to maintain themselves, and rapid prostration follows. There are cases, however, with animals as with men, in which the forces of the body triumph over the disease, and the progress of the tubercular formation is arrested. The tubercular material is then enclosed by fibrous walls, which shut if off from the living tissues of the body, caseation and softening or calcification take place, and in the course of time the bacilli may die and disappear. Unfortunately, these cases are the exception and not the rule.

General Appearance.—The inspection of a herd of cattle affected with tuberculosis frequently reveals evidence strongly indicative of the presence of the disease.

In those cases which progress to a fatal end the attitude and general appearance of cattle are quite characteristic during the final stages.

Some of the animals may be emaciated, the skin tensely drawn over the bones, the hair standing on end, rough and lustreless, and the eyes sunken in their sockets.

The animals remain almost constantly standing ; the noses are raised, and the heads extended on a line with the necks ; the elbows

1. D. E. Salmon, B. A. I., Bull. No. 38, p. 21.

are turned out to facilitate the expansion of the chests; and there are haggard expressions to the faces in harmony with the general appearance of the bodies.

If the history of the herd shows that occasionally an animal lost flesh, yielded a decreased quantity of milk, and gradually pined away until it died, or it became necessary to kill it, tuberculosis should be suspected.

Lung

In examining the individual animals the object is to learn the conditions of the organs most frequently the seat of tubercular disease. As the lungs are affected in from 60 to 75 per cent. of the cases, these organs should receive careful attention. With tuberculosis of the lungs the most prominent symptom is a cough; this is persistent, short, dry, strong, and often high in pitch, almost whistling. As the disease advances the cough is more prolonged, violent, convulsive,[1] and may be accompanied by protrusion of the tongue. Auscultation[2] reveals various modified and abnormal sounds in the lungs. There may be friction sounds, the result of disease of the pleura, increased respiratory murmur from bronchial irritation, loss of respiratory murmur from large tubercular deposits or adhesions, mucus râles from the inspired air being drawn through collections of mucus in the air tubes, and whistling sound from thickening of the walls of the bronchial tubes. Percussion over the chest walls may in some cases show abnormal resonance from the tubercular deposits causing portions of the lungs to recede from the ribs; but in a larger number of cases there are areas of dullness corresponding to tubercular masses. In many cases with severe lesions of the lungs no satisfactory evidence can be obtained by either auscultation or percussion.

In case the serous membranes of the chest become irritated by the tubercular deposits, pressure applied over the ribs may cause the diseased animal to cough, moan, seek to escape, and otherwise manifest evidence of tenderness in this region.

Mediastinal glands

The mediastinal glands are situated between the lobes of the lungs, and rest upon the esophagus. Very often in tuberculosis they are diseased and enormously enlarged, and in such cases they press upon the esophagus and cause digestive disturbance, more particularly chronic bloating, which may appear regularly soon after eating, no matter what the character or the quantity of the food taken. Habitual bloating, when the food is of good quality and taken in proper amount, and when there is no other evidence of disease of the digestive organs, is considered strongly indicative of tuberculosis with enlargement of these glands.

Stomach

In tuberculosis of the stomach and intestines digestion is, more or less, interfered with, the appetite becomes poor or irregular, and there

1. "....and occasionally bronchial discharges may issue from the mouth after a severe fit of coughing."—Williams, Veterinary Medicine, Ninth Ed., p. 354.
2. "Auscultation"—the act of listening; use of the stethoscope.

is frequently diarrhœa or diarrhœa alternated with constipation. There may also be bloating and colicky pains.

Uterus

With tuberculosis of the uterus and ovaries, and sometimes with peritoneal tuberculosis, the cow remains almost constantly in heat, but is often sterile. When the post-pharyngeal glands are affected there is interference with the breathing, which becomes harsh and loud; there may also be difficulty in swallowing. It is sometimes possible to feel the enlarged glands by placing one hand on each side of the throat and then pressing with both hands over the region of the throat above the larynx.

Brain

In case tubercles form in the brain or spinal cord the symptoms vary somewhat, according to the part affected. The first signs are depression, soon followed by stiffness and unsteadiness of the gait. The animal lies down a great deal and rises to its feet with difficulty. As the disease advances there may be cramps of the muscles of the neck and local paralysis, causing difficulty of swallowing. The food is retained a long time in the mouth, and is finally dropped into the manger. Sometimes the symptoms are those of acute meningitis, when the animal is nervous, excitable, frenzied, and may have convulsions and coma. Usually the spinal cord and brain are affected at the same time, the effect of disease of the cord being to make locomotion more and more difficult and to bring about paraplegia[1] and paralysis of the posterior extremities.

Tongue

With tuberculosis of the tongue the lesions may be localised or disseminated throughout the organ. In the former case the tongue preserves its mobility, but on examination a swelling may be detected in some part of it, which is hard and embedded in the tissue. As the tubercular process advances an ulcer forms on the upper surface of the tongue over the swelling, which is covered with a firm yellowish exudate. When the tubercular deposit is diffused through the organ the tongue loses its mobility, becomes hard, and has an appearance similar to the "wooden tongue," which occurs in actinomycosis. The diagnosis is made by a microscopical examination of the affected tissues.

Joints

Tubercular inflammation of the stifle joint, and less frequently of other joints, may occur during the progress of the disease. The affected joint is swollen, warm, and very painful. There is great lameness, and the animal is hardly able to put its foot to the ground. Such inflammations of the joints in cattle and hogs should lead to the suspicion of tuberculosis.

Sometimes the tuberculous process is localised in the trachea and larynx, and this may occur either in connection with lesions of other organs or independent of them. The respiration is harsh and loud and accompanied by a mucus râle or gurgling sound, caused by the accumulation of mucus in the trachea. In such cases there is

1. "Paraplegia"—paralysis.

a frequent and troublesome cough, which is easily excited by pulling on the tongue or by slight pressure upon the larynx. The animal stands with the nose raised, the head extended upon the neck, and avoids lateral movements of the head and neck on account of the tenderness of the affected region.

Udder

The diagnosis of tuberculosis of the udder is a matter of extreme importance, on account of the danger from infected milk. Great attention has, therefore, been given to this subject by many investigators. A recent and very minute study of mammary tuberculosis has been made by Ostertag, Breidert, Kaesewurm, and Krautstrunk,[1] and we are now able to speak with some confidence both as to the methods of examination and the symptoms which are usually found. Tuberculosis of the udder is indicated by swelling and hardening of one or more quarters. It usually begins in one of the posterior quarters and takes a chronic course. The swelling causes the teats of one half of the udder to assume a parallel or converging direction, instead of diverging from one another. A healthy quarter feels soft or moderately firm throughout; in milch cows the normal elastic tissue often contains symmetrical, firm masses of varying size formed by the lobules of the gland. A tuberculous quarter feels irregular from the beginning of the disease. Certain portions, especially toward the back of the udder and over the milk cisterns, are firm, stiff, or as hard as wood. The firm parts form more or less sharply margined lobules, distinct from the normal elastic tissue. The tuberculous swellings increase in circumference, and in time their surface becomes nodulated.

When the udder is distended the tuberculous swellings are often difficult to detect, but in the relaxed condition of the organ after milking this difficulty disappears. The swellings are painless and of the same temperature as their surroundings. The milk of the diseased quarter may remain apparently normal for weeks, but as the tuberculous process extends and destroys the secreting tissue, it changes in appearance, becomes thin, flocculent, and finally watery. At this time it often exhibits an alkaline reaction instead of the normal neutral reaction.

In exceptional cases tuberculosis of the udder may commence with acute inflammation, or may for a time assume an acute course. The lymphatic glands of the diseased quarter or half are always swollen. Their condition can most conveniently be examined by thrusting the skin covering the side of the diseased hind quarter upward, toward the flank, with the index, middle, or ring finger, and palpating the posterior and lateral aspects of the glands in question. When diseased, the glands are found to be enlarged in all directions; sometimes their surface is nodulated.

1. Ztsch. f. Fleisch. u. Milchhyg., Jhr. 15, Hft. 1, pp. 1-10, Berlin, Oct., 1904. Translation in Jour. of Comp. Path. and Ther., Vol. 18, pt. 1, pp. 84-6, Edinburgh and London, Mar., 1905.

Actinomycosis and streptococci infection

Disease simulating tuberculosis of the udder may be produced by chronic infection with streptococci, or with actinomyces (see Appendix A, p. 409). In the chronic inflammation due to streptococci the lymph glands are greatly enlarged, but are not nodulated. In actinomycosis of the udder the lymph glands are seldom much enlarged.

Symptoms of Tuberculosis in Pigs.

Hogs

The symptoms of tuberculosis in hogs are very obscure and difficult to detect. In the great majority of cases no symptoms are noticed, and the disease is only recognised by an examination of the carcass. The parts most frequently affected are the glands of the neck, the bronchial, mediastinal, mesenteric, and portal glands, the liver, lungs, kidneys, and spleen. In numerous cases the glands of the carcass are affected, and tuberculosis of the bones and joints is common.

Although there is a great tendency for tuberculosis to spread to different parts of the body in swine, causing it to become more frequently generalised with these animals than with cattle, the rapidity with which they take on fat apparently enables them to resist the destructive influence of the disease, at least to the age at which they are generally slaughtered. Animals which come to market fat, and appear perfectly well just before slaughter, may be found quite seriously diseased.

In some cases, however, swine may show enlargement of the glands of the neck and of other parts of the body, diarrhœa, emaciation, and tubercular inflammation and swelling of one or more joints. When the nutrition of the body is affected, as shown by loss of flesh, the disease usually runs a rapid course and causes death of the animal in a few weeks.

PSEUDO-TUBERCULOSIS.

"Under the term pseudo[1]-tuberculosis are included," says Ostertag,[2] "pathological processes which, without being caused by the tubercle bacillus, have the essential character of caseation in common with tuberculosis. The etiology[3] of so-called pseudo-tuberculosis is exceedingly multiform. Micrococci, bacilli, cladothrices, and mould fungi may cause tubercle-like processes. Formerly tubercles produced by animal parasites were classified with the pseudo-tuberculous processes; for example, when degenerated tapeworm larvæ were present in the musculature, one spoke of cestode tuberculosis. Ebstein and Nicolaier accepted this term for verminous tubercles in the kidneys of dogs and in the lungs of cats.

"**Occurrence**—Tubercle-like alterations which were not produced by the tubercle bacillus were observed by Eberth, Pfeiffer, and other

1. "Pseudo"—false.
2. Handbook of Meat Inspection, 1904, p. 652.
3. "Etiology"—cause.

authors in guinea-pigs and rabbits ; by Melassez and Vignal in chickens ; by Mégnin and Mosny in horses ; by Hayem, Toupet, and Eppinger in man ; and, finally, also by a large number of observers in food animals, especially cattle and sheep. In the last-named animal, pseudo-tuberculosis may appear as an epizootic, as has been the case of late years in Australia and America."

[1]" Preisz and Guinard reported concerning a case of pseudo-tuberculosis in a sheep. Both kidneys of a sheep, which was slaughtered in an abattoir, were covered with old calcified granules, which greatly resembled tubercles. Koch's bacillus, however, could not be demonstrated in the granules. By the inoculation of rabbits and guinea-pigs the authors uniformly obtained positive results : a rapid generalisation of small tubercle-like structures, which contained large quantities of very delicate fresh bacteria, rounded at both ends. This micro-organism could also be demonstrated in the tubercles of the sheep kidneys. Preisz and Guinard are of the opinion that the bacterial pseudo-tuberculoses are all identical. Later Preisz called attention to the fact that the pseudo-tuberculosis investigated by him was distinguished from true tuberculosis by the fact that, in the former, tubercles were rapidly produced and casefied immediately after their appearance, while true tubercles do not become visible and begin to calcify until three or four weeks after inoculation."

[2]Diagnosis and Differential Diagnosis.

" The general symptom of pseudo-tuberculous processes, *caseation*, has already been mentioned. Pseudo-tuberculosis has this symptom in common with true tuberculosis. For the differentiation of the two processes, the casualistic[3] material furnishes essentially two criteria : first, the pseudo-tuberculous tubercles appear, as a rule, not to contain giant cells or epithelioid cells ; furthermore, it is to be concluded, from observations thus far made, that the caseous foci, which appear in the lymph glands in pseudo-tuberculosis, do not calcify, but dry up, and, consequently, exhibit an onion-like stratification.

" **Judgment.**—The sanitary police judgment of pseudo-tuberculous alterations varies like their etiology. In all cases, however, the character of the process justifies the complete exclusion from the market of organs which are affected with the alterations in question, and of the meat which is sympathetically affected by the generalisation process."

It is thus clear that tubercles may result without tuberculosis, but apparently the instances in bovines are somewhat rare. Chas.

1. Ostertag's Handbook of Meat Inspection, p. 653.
2. Ostertag's Handbook of Meat Inspection, p. 654.
3. "Casualistic"—descriptive of the history of a case of disease, such as contained in a veterinary or medical diary.

A. Squair, M.R.C.V.S.,[1] Reigate, goes farther, however, in maintaining that "....tubercle and tuberculosis are two entirely different diseases." "The flesh of an animal suffering from tubercle," he says, "is fit for food; the flesh of an animal suffering from tuberculosis is not fit for food." We hardly need point out that this thesis is entirely in opposition to the well-established beliefs of modern veterinary pathologists, and is negatived by an overwhelming mass of experimental evidence, of which we shall obtain a glimpse in the following pages.

Stockman,[2] for instance, states that "In the ox about 99 per cent. of tuberculous looking lesions in the internal organs will be found due to the tubercle bacillus."

DETECTION OF TUBERCULOSIS OF THE UDDER.

"The clinical diagnosis of tuberculosis of the udder may be regarded as assured when one quarter of the udder and its attached lymph glands exhibit firm, hard, nodulated swellings without signs of inflammation. When the quarter and attached lymph glands exhibit only firm, hard swellings, without nodulation, the diagnosis is somewhat doubtful. Suspicion, however, will be increased if the milk from the suspected quarter is of apparently normal constitution, or appears, from the history, to have been of normal constitution at the commencement of the disease. The probability of tuberculosis is again increased by the existence of any other clinical indications of the disease, such as (1) general falling off in condition; (2) continued fever without apparent acute disease; (3) painless nodulated swellings of the pharyngeal, prescapular, or precrural lymphatic glands without symptoms of inflammation; (4) frequent, spontaneous, weak cough, and pneumonic râles without apparent acute inflammation; (5) frequently recurring tympanites[3] without apparent cause; (6) frequent œstrum and mucopurulent discharge from the vagina; (7) reaction to the tuberculin test. In rare cases symptoms of tuberculosis of the brain and tuberculosis of the vagina may lend additional weight to the suspicion of tuberculosis of the udder.

"Portions of the prescapular and precrural glands may be removed without danger. Removal of portions of the mammary lymph glands is somewhat difficult on account of the deeper position of these parts, but is also without danger. Macroscopic examination of such fragments is often sufficient to reveal the tuberculous nature of the disease."

Quite a considerable amount of evidence is available indicating the very limited reliability of physical examination for detecting tuberculosis.

1. See The Farmer and Stockbreeder, Nov. 21st, 1910, p. 2116.
2. Walley's Meat Inspection, 1909, p. 90, re-written and enlarged by Stewart Stockman, M.R.C.V.S. W. Green & Sons.
3. "Tympanites"—flatulent distension of the abdomen.

Value of clinical examination

Ward[1] says, "A cow may be in fine condition and apparently perfect health, and on slaughter show the most serious advanced stage of involvement of the internal organs. This is so common that the diagnosis by physical examination by a veterinarian is entirely unsatisfactory.[2] While some advanced cases of tuberculosis can be recognised by physical examination, such an examination will reveal but a small percentage of the cases capable of disseminating infection."[3] On the other hand, the appearance of emaciation may be deceptive. "The good dairy cow certainly is emaciated at times, and this, in conjunction with an old coat of hair, gives a miserable appearance. Under the circumstances, emaciation as a symptom of tuberculosis cannot be given very heavy consideration."

Emaciation

Ward's personal experience in physical examination of dairy herds for tuberculosis has been most unsatisfactory. [4]"About 300 cows, supplying a town with milk, were examined once in each of two successive years. Cows showing definite unmistakable physical signs of tuberculosis, warranting slaughter, were not found, but three excited strong suspicion. The dairymen, either in accordance with regular practice, or on account of the moral effect of the inspection, had removed the cows that persistently coughed. In the third year, the tuberculin test revealed the fact that 30 per cent. of the cows were tubercular."

Ward also mentions two other cases in which physical examination failed to reveal tuberculosis in cattle. In a group of 64 tubercular cows only nine could be detected clinically, and in another case "....a recognised expert on bovine tuberculosis examined 378 reacting cows, and was able to recognise only 21 as tubercular by means of physical examination." Ward, therefore, concludes that "....the tuberculin test is the only available means for the detection of tuberculosis in cattle."

Professor Jesse E. Pope[5] remarks that veterinarians venture to assert that physical examination can discover animals in the advanced stage of the disease, "....but the farmer's experience is against this contention, for in many instances such cattle have passed the physical test and yet have died from the disease a few months later."

Jobson[6] says that "....physical examination will only detect the disease in its advanced stages when the animals are about useless for the butcher or the dairy."

Deering,[7] who supervises the control of tuberculosis in the State of Maine, U.S.A., tells us that "If Maine had followed out the policy

1. Pure Milk and the Public Health, p. 60.
2. This statement is strongly objected to by some British veterinarians, who state that the Americans disregard the incalculable value of the use of the clinical thermometer. We cannot speak too highly of its value in the diagnosis of tuberculosis.
3. Pure Milk and the Public Health, p. 68.
4. Pure Milk and the Public Health, p. 69.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 577.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 766.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 916.

of only condemning cattle by a physical examination, she would, to-day, have a percentage five times greater than she has, and I am glad to say that when the Cattle Commission report to the next legislature in January, it will be that out of some 25,000 cattle tested with tuberculin there were only a little over $3\frac{1}{2}$ per cent. found diseased."

Hughes[1] points to the "....absurd fact that a physical examination only, without the tuberculin test, is all that is required to pass animals into New Hampshire. Reimbursement is given in the State for animals found, on physical examination, to be tuberculous, that is, New Hampshire waits until the tuberculous animal has done its worst and is rapidly approaching death before it acts."[2]

Deering relates a striking instance of the folly of reliance on physical examination (see p. 341). Still further evidence is afforded by Schroeder (p. 106), and by Mohler and Washburn (p. 191).

As a measure for the eradication of bovine tuberculosis, the elimination of tuberculous udders is regarded by Dr. Scurfield[3] as a "clumsy makeshift," and was compared by the late Professor Owen Williams with an attempt to destroy a bed of mushrooms by gathering the crop each morning.

The veterinary inspector in charge of control of bovine tuberculosis in Massachusetts takes a similar view (see Reynolds[4]). It may be that New Hampshire does not worry over eradication any more than we do in Britain. We do not permit dumping of tuberculous cattle, however, except for immediate slaughter at the port of debarkation, while the abattoir records show the animals to be very healthy.

"With regard to tuberculosis of internal organs," Delépine[5] says, "a comparison between the results obtained by clinical examination and by tuberculin testing (confirmed by *post-mortem* examination) shows that the proportion of tuberculous cows that escape detection, when the clinical method alone is used, is very considerable. For administrative purposes, the clinical method is quite insufficient and unreliable, and if adopted generally would give rise to serious difficulties."

EXAMINATION OF THE CARCASS.[6]

"The carcasses of all animals which die or are slaughtered from a herd should be carefully examined to determine whether they are affected with tuberculosis. This is an important means of learning as to the existence of the disease, and may give an early warning when its presence has not been suspected. The examination of carcasses is especially necessary with swine, since the tuberculin test is not

1. 6th I. C. on T., Vol. 4, pt. 2, p. 964.
2. This state of affairs has since been remedied.
3. Annual Rept. on the Health of the City of Sheffield for the year 1909, p. xv.
4. 6th I. C. on T., Vol. 4, pt. 4, p. 932.
5. Pro. Roy. Soc. Med., Vol. 3, No. 7, Epidemiological Sect., May, 1910, p. 254.
6. D. E. Salmon, B. A. I., Bull. 38, p. 52.

generally used and is rather unsatisfactory with these animals.[1] An examination of the carcasses of all animals from a herd is an easy and accurate way of keeping informed as to the condition of health of that herd, and particularly as to the existence of any form of infection, or of any injurious parasites.

"....Any farmer or dairyman should, with a little practice, be able to recognise tubercular lesions in most cases, or should at least be able to tell if there is anything having the general appearance of tuberculosis, and in case of doubt the affected organ may be saved and taken to a veterinarian for an expert opinion."

[2]"**Appearance of the Diseased Organs.**—The word 'consumption' is often applied to tuberculosis, and thus many have been led to believe that tubercular organs are shrivelled or shrunken in size, *i.e.* consumed by disease. On the contrary, a tubercular organ, especially in domestic animals, is usually larger, often several times larger, than normal. The lymph glands especially become enormously enlarged, and if such enlarged glands are in the neck, may often cause difficulty in breathing, due to the pressure on the windpipe. The lungs frequently may be much enlarged, often weighing several times as much as healthy organs. Hard bunches, or swellings, are usually present in the diseased organs, and are the cause of the enormous increase in size so often noted.

"**Internal Appearance of the Tubercles.**—The smaller tubercles when cut show a uniform, grey colour. As they increase in size a small yellow mass, which slowly enlarges, is developed in the centre. The larger tubercles are often filled with creamy, yellow pus. Again, they may be hard and gritty, due to the deposition of lime salts. This condition is known as *calcification*. When the blade of a knife is drawn across the cut surface a scratching sound is heard.[3] The appearance is that of yellow, granular material, which often reminds one of cornmeal. The large cavities filled with pus are usually called tubercular abscesses. They are found in the lungs, liver, and lymphatic glands. The material within the tubercle contains the tubercle bacilli.

"**How does a Tuberculous Udder appear ?**—The healthy udder is uniformly soft, while the tuberculous udder contains the hard tubercles, which, when near the surface or when large, can be felt. As the disease progresses, the infected quarter (for the disease is generally confined to one quarter) becomes enlarged and hard. There is, however, no fever nor pain, and the swelling does not disappear, as in the case of garget (inflammation of the udder), but continues

1. Salmon also states in a footnote that "Experiments recently made by the Bureau of Animal Industry in testing hogs with tuberculin indicate that the application of the test to these animals is practicable, and that the results are as reliable as with cattle, provided the hogs are kept very quiet for some time before and throughout the test" (B. A. I., Bull. 38, p. 52, 1906).
2. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 4.
3. Nocard compared this to cutting mortar.—The Animal Tuberculoses. p. 11.

to grow more pronounced. The milk is usually normal in appearance and composition but in severe cases may become watery.

" Examination of a Carcass for Tuberculosis.—The general appearance of the different parts of the body to be examined should be carefully noted; they should be carefully felt for tubercles, and if any suspicious places are discovered the organ should be cut. Unless one has had some experience in such examinations it is advisable to cut the various glands and organs, even though no suspicious places are found.

" The head should be severed as usual and the glands of the throat (*pharyngeal*) removed and examined for enlargements. Cut each gland into several slices and note the presence of any yellowish or greyish-yellow areas. A healthy gland is light grey or pinkish in colour throughout, or in old animals is often dark, or almost black, from pigment.

" Remove the udder, examine carefully for bunches (tubercles); also examine the lymph glands just above the hind quarters of the udder.

" Open the abdominal cavity. Examine liver, spleen and kidneys, first noting their general appearance. If any yellowish areas are found, cut through at this point. Note whether the membranes covering the stomach, etc. (the omentum or caul) are smooth and thin, or studded with nodules or tubercles.

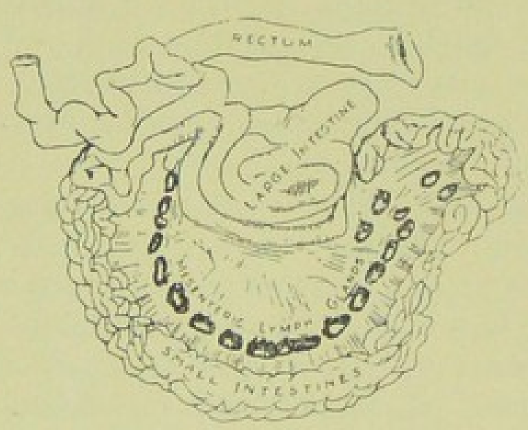


FIG. 1.—Location of the mesenteric lymph glands with relation to the intestines.

" The intestines proper should be examined, although the disease is rarely found on the gut wall itself. The disease is much more likely to be found in the mesenteric lymph glands (Fig. 1),[1] which run parallel to the intestines several inches from the same, in the membrane that holds the intestines in place. Examine the uterus and the walls of the abdominal cavity, which should be perfectly smooth.

" Open the lung cavity, remove the lungs, together with the gullet, windpipe and heart entire. Healthy lung tissue is uniformly soft and pink in colour. Remove the glands (Fig. 2) on the windpipe and gullet, and especially those at the forks of the windpipe, and note whether they are enlarged or not. Cut open in order to discover small tubercles.

" If the animal is tubercular, evidences will usually be found in the parts of the body mentioned, but its non-detection in these parts is not absolutely positive evidence of the absence of the disease in the animal, for in the earlier stages nodules of small size may be readily overlooked.

" What Diseases may be mistaken for Tuberculosis?—In the case

1. Figs. 1 and 2 are reproduced from Russell and Hasting's Circular of Information No. 23, Wis. Agri. Exp. Stn.

of lumpy jaw (actinomycosis) nodules may be formed in the lungs and udder that closely resemble those of tuberculosis (see Appendix A). In sheep the wall of the intestines may show a nodular condition, known as 'nodular disease' or 'knotty gut,' caused by a minute animal parasite that burrows its way into the wall of the intestine."

In making an examination after slaughter, we should, naturally, be interested in abnormal conditions of any nature whatever. Exact and exhaustive details of *post-mortem* examination may be found in the excellent work of Leighton and Douglas,[1] but the enterprising cattle owner will do very well if he succeed in grasping a pithy, concise description such as that by Mr. Harold Sessions[2] in his admirable little work Cattle Tuberculosis.

Mr. Sessions' account is reprinted hereunder.

"If the inspection is made at the time of the slaughter, the organs will be examined as they are removed by the butcher in his customary way of dressing, which is much the same in all animals.

"To prevent repetition, I may mention a rule to be observed in the examination of all organs. Their size, shape, colour, and consistency should always be criticised, also their outlines and relationships, after which one may search for pathological changes. A regular inspection is of extreme importance, as it will help one to trace the development and course of most diseases.

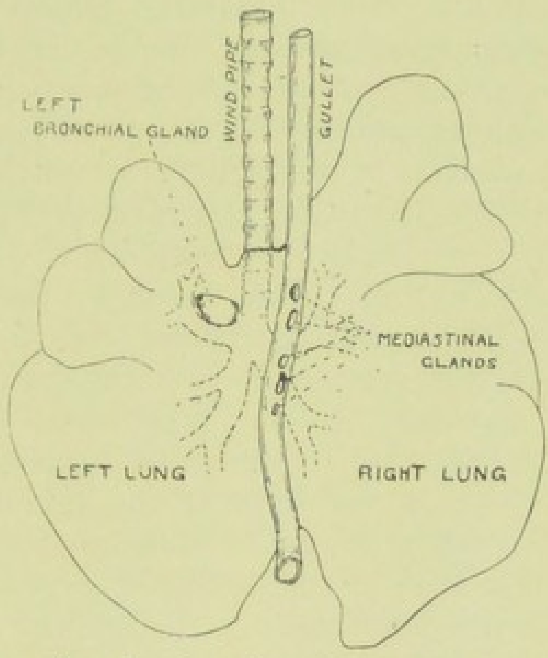


FIG. 2.—Location of bronchial and mediastinal glands[3] on the windpipe and gullet. The left bronchial gland occurs at the first branch of the windpipe and is just outside the lung tissue. The right bronchial glands are very small or may be absent. The mediastinal glands lie close to the wall of the gullet, and are small irregular bodies about one and a half inch in length normally.

"*The Feet.* — These require examining for injuries, septic changes, morbid growths, eruptions of foot-and-mouth disease, etc.

"*Intestines and Mesenteric Glands.*—The bowels are used as a capsule for our black puddings and polonies. Their calibre and peritoneal covering and the thickness of their walls should be noted.

1. The Meat Industry and Meat Inspection. The Educational Book Co., Ltd., London.
2. Cattle Tuberculosis, by Harold Sessions, F.R.C.V.S., F.H.A.S., F.R.G.S., p. 83. Baillière, Tindall & Cox.
3. Salmon states that the bronchial and mediastinal glands are more frequently affected than the lungs themselves (B. A. I., Bull. 38, p. 52). The reason that so much importance attaches to these glands is that the lymph coming from the intestine passes first through the mesenteric glands and that from the lungs passes in the same way through the bronchial glands.—See Delépine, The Lancet, Sept. 17th, 1898, p. 734.

"The mesenteric lymphatic glands in bovines are to be found running along the mesentery near its distal border, about 4 inches from the attachment to the small intestines. Their examination should never be overlooked in conducting a *post-mortem* examination for evidence of tuberculosis, and especially in proving the tuberculin test. The intestines should always be condemned when their peritoneal covering or lymphatic glands are diseased.

"*The Stomachs.*—The first stomach is commonly called the belly, and after it has been scalded, scraped, and boiled, it constitutes tripe. The third stomach is not used, but the fourth is also converted into tripe. The average weight of the first stomach is from 16 to 20 lbs. Some lymphatic glands will be found in the fat near the esophageal entrance, and in the fissure on its anterior surface. The peritoneal surface of the stomachs is frequently affected with tuberculosis, and the mucous membranes of the fourth stomach with worm tubercles, a description of which is given by Professor M'Fadyean in the Journal of Comparative Pathology (vol. 9, p. 314).

"*The Liver.*—The normal weight of the ox liver is about 10 to 12 lbs. It varies, however, very greatly, even in health. It is a common seat of disease, such as inflammatory changes resulting in fatty degeneration, cirrhosis, parasitic infection (fluke, hydatid cysts), abscesses, tumours (carcinoma, cavernous angeiomata, etc.), tuberculosis, and disseminated bacterial necrosis.

"In the liver of the rabbit the parasitic infection known as coccidian disease is sometimes met with and mistaken for tubercle. The liver is studded with greyish-white nodules, varying in size from a pea downwards, with purulent contents, which are found on microscopical examination to contain great numbers of coccidium oviforme. The individual coccidia are egg-shaped bodies, possessing a shell wall with protoplasmic contents. In some seasons an epidemic form of this disease occurs in rabbit-warrens.

"Disseminated bacterial necrosis has also been mistaken for tubercle. The two diseases, however, are quite easily distinguished. Briefly, in this disease necrosed patches or areas are irregularly distributed through the liver substance, varying in size from a walnut downwards, with a well-defined outline, which is not circular; in colour the patch of dead tissue varies from brownish-yellow to a dirty grey, and in consistency it resembles putty or unripe cheese, is not purulent, and cannot be easily enucleated from the surrounding tissue. On the surface of the liver the nodules are slightly raised, yet somewhat flattened on their upper aspect and firm to the touch. The lymphatic glands will be free from tubercular deposit. It may be also said the liver is usually very much enlarged. The hepatic glands are to be found at the portal fissure.

"*The Spleen.*—Commonly called the melt.[1] Its external surface

1. Melt, or "Milt" according to Russell and Hastings, Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 3.

is frequently affected with tuberculosis, and occasionally the splenic pulp also. This organ is important in the diagnosis of anthrax; particular attention should therefore be paid to its volume and consistency. Its lymphatic glands are usually left attached to the left side of the stomach.

" *Uterus.*—Also termed the calf-bed, or lamb-bed, as the case may be. Inflammatory diseases, tuberculosis, and septic conditions are chiefly looked for.

" *Heart and Lungs.*—These organs are removed from the chest, together with the mediastinal tissue and fat attached. It is important that the following lymphatic glands should be looked for, namely:

" 1. *Tracheal Glands.*—On the course of the trachea, on its upper surface.

" 2. *Cardiac Glands.*—At the base of the heart, and must be looked for before the organ is severed from the lungs.

" 3. *Bronchial Glands.*—At the bifurcation of the trachea into the two bronchii. The right gland is sometimes torn away, but the left is always to be found by cutting down on the left bronchial tube.

" 4. *Mediastinal Glands.*—This group of glands will be found in the form of a chain running in the mediastinal tissue between the right and left lungs on the esophagus. They are of large size.

" The lungs must not be stripped of their fat until these four groups of glands have been examined, otherwise they will be removed. Their examination is necessary in all inflammatory and blood diseases, and in tuberculosis they should never be overlooked. They are frequently found affected when this disease is not apparent in the lung tissue—an item to be remembered in making *post-mortem* examinations after the tuberculin test. All other diseases of the lungs and heart are, of course, to be looked for.

" *The Mammary Glands, or Udder.*—The mammary glands are two in number, and are placed side by side on the middle line of the abdominal wall in front of the pubes. They form here a single mass, with a furrow between them; each gland consists of a fore- and hind-quarter. The term 'udder' is used to include both glands.

" The udder of the cow when boiled constitutes an article of diet in the tripe-shop. The examination thereof is important. Each quarter should be criticised in respect to volume and consistency, and an incision should be made from the ampulla right through the whole gland, dividing it into halves. The milk-ducts and gland tissue will then be well exposed, and its peripheral borders and ducts should be carefully examined.

" *The Lymphatic Glands of the Udder.*—Situated at the supra-posterior border of each gland, near the entrance of the blood vessels—that is to say, above the attachment of the hind-quarters. Their examination is extremely important in all inflammatory diseases, tuberculosis, and septic affections of the udder.

"*Pharyngeal Glands.*—Situated at each end of the pharynx, and related to the inner surface of the great cornu of the hyoid bone, near its attachment to the skull. They are easily got at by placing the head on the table, face downwards, with its base towards you, the examiner raising the cut-end of the trachea with the left hand, feeling for the hyoid bone, and making the incision. They are frequently seen without any dissection when the tongue is removed.

"*Submaxillary Glands.*—Found at the angle of the lower jaw, at the inner side of the attachment of the sterno-maxillaris.

"*Parotid Gland.*—At the anterior border of the parotid salivary gland, resting on the masseter muscle.

"*Suboccipital Glands.*—At the base of the occipital bone, near the condyles.

"*Mammary or Superficial Inguinal.*—These have been already alluded to. In the bullock they are to be found at the base of a mass of fat known as the 'cod' in the inguinal region, and are readily brought to view by making a bold incision in this fat from the inner surface and cutting down upon the abdominal tunic. In the pig these glands are to be found in the subcutaneous fat above and a little posterior to the last teat in the inguinal region.

"*Deep Inguinal Glands.*—This large group of glands is to be found at the pelvic inlet, in the distal edge of the loin suet and on the course of the external iliac artery, about midway between its departure from the aorta and its entrance into the thigh muscles.

"*Iliac Glands* (*External and Internal*).—These are related to the arteries of the same name at their origin about the last lumbar vertebra.

"*Sacral Glands.*—Situated at the flow of the sacrum between the two internal iliac vessels.

"*Lumbar Glands.*—These may be described as a superficial and deep set. The superficial chain, which perhaps belong to the large bowels or their mesentery, are to be found in the fat in front of the large vessels in this region. The deeper set are situated close on to the lumbar vertebræ.

"Another group of glands is to be found in the fat of the loins, resting on the muscles of the flank a few inches anterior to the deep inguinal, and at the point where the circumflex iliac artery divides into its anterior and posterior branches.

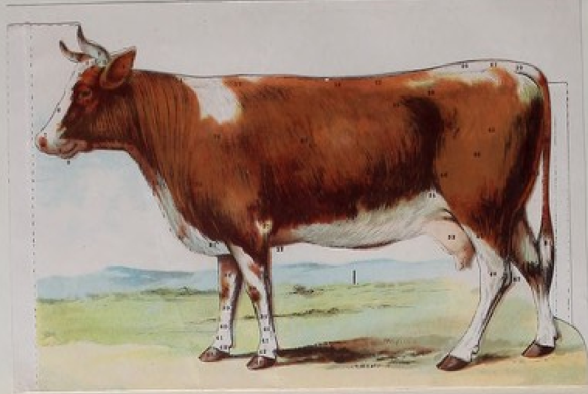
"*Renal Glands.*—At the origin of the renal artery, about the second lumbar vertebræ.

"*Cœliac Glands.*—Between the pillars of the diaphragm at the origin of the cœliac axis.

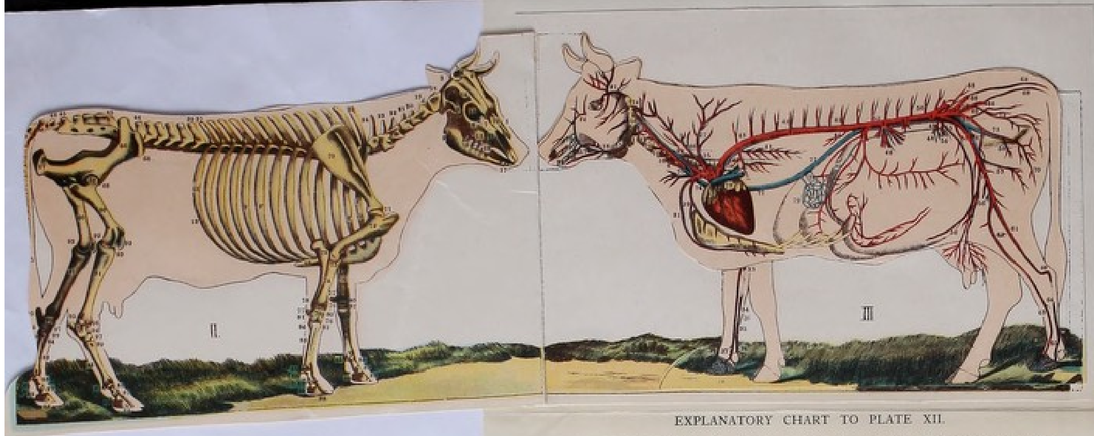
"*Popliteal Glands.*—These glands are to be found in the popliteal space, and are readily got at by cutting through the thigh muscles immediately above and posterior to the stifle-joint (femoro-patellar articulation) on the track of the femoro-popliteal artery.

"*Precrural Glands.*—Of large size, and found in the groin fascia. The landmarks for its section are at the superior border of the

PLATE XII.



EXPLANATORY CHART TO PLATE XII.



EXPLANATORY CHART TO PLATE XII.

I.—DIVISION OF THE BODY OF CATTLE.

Head.

1. Back of head.
2. Frontal crest.
3. Horns.
4. Ears.
5. Forehead.
6. Bridge of nose.
7. Nostril.
8. Mouth, with upper and lower lips.
9. Chin.
10. Throat channel.
11. Cheeks.
12. Eyes and eyelids.

Neck.

13-14. Nape of the neck.
15. Throat.
16. Dewlap.

Body.

17. Withers.
18. Back.
19. Loins, or kidney region.
20. Chest wall.
21. Front breast.
22. Lower breast.
23. Belly.
24. Flanks.
25. Hunger pit.
26. Rump.
27. Croup.
28. Hips, or haunches.
29. Root of tail.
30. Tail.
31. Tassel, or ball.
32. Udder, with the teats.
33. Perineum, with the [illegible] shield.

Fore Limbs.

34. Shoulder.
35. Shoulder joint.
36. Forearm.
37. Elbow.
38. Knee.
39. Shin bone.
40. Fetlock joint, with the hind claws.
41. Pastern.
42. Coronet.
43. Claws, or hoofs.

Hind Limbs.

44. Upper thigh (upper part of the thigh).
45. Hip joint.
46. Stifle joint.
47. Lower thigh.
48. Hock.
49. Point of hock.

From the hock downwards the designations are the same as on the fore limb.

II.—THE SKELETON.

Head.

[illegible]

III.—BLOOD CIRCULATION.

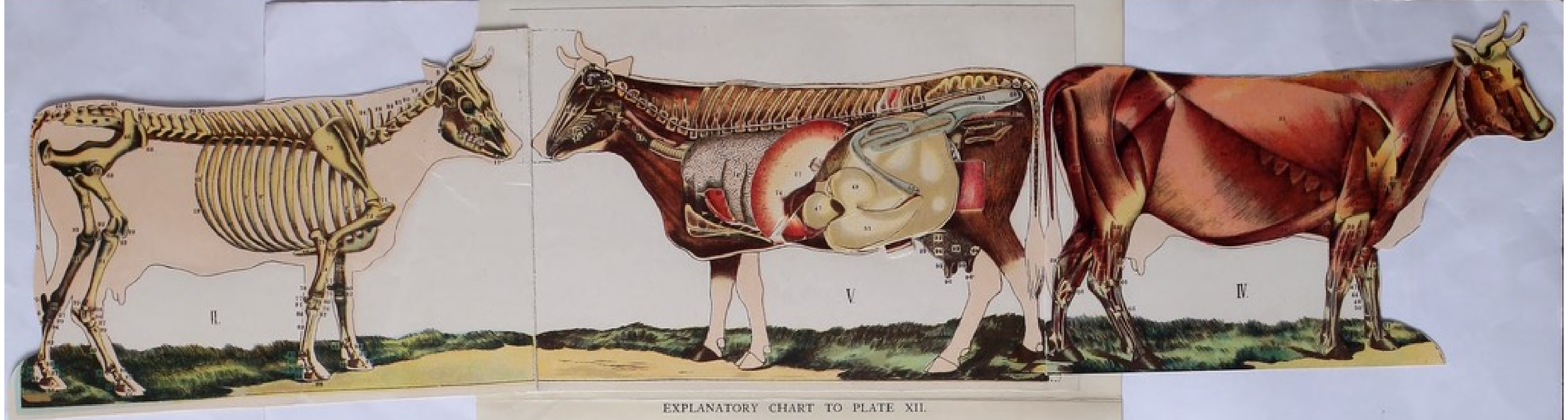
[illegible]

IV.—THE MUSCLES.

[illegible]

V.—THE BOWELS AND PARTIAL MEDIAN SECTION OF THE BODY.

[illegible]



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22. Lower breast.
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24. Flanks.
25. Hunger pit.
26. Rump.
27. Croup.
28. Hips, or haunches.
29. Root of tail.
30. Tail.
31. Tassel, or tuft.
32. Udder, with the teats.
33. [illegible]

Front Limbs.

34. Shoulder.
35. Shoulder joint.
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37. Elbow.
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49. Point of hock.

From the hock downwards the designations are the same as on the front limbs.

II.—THE SKELETON.

[illegible]

III.—BLOOD CIRCULATION.

[illegible]

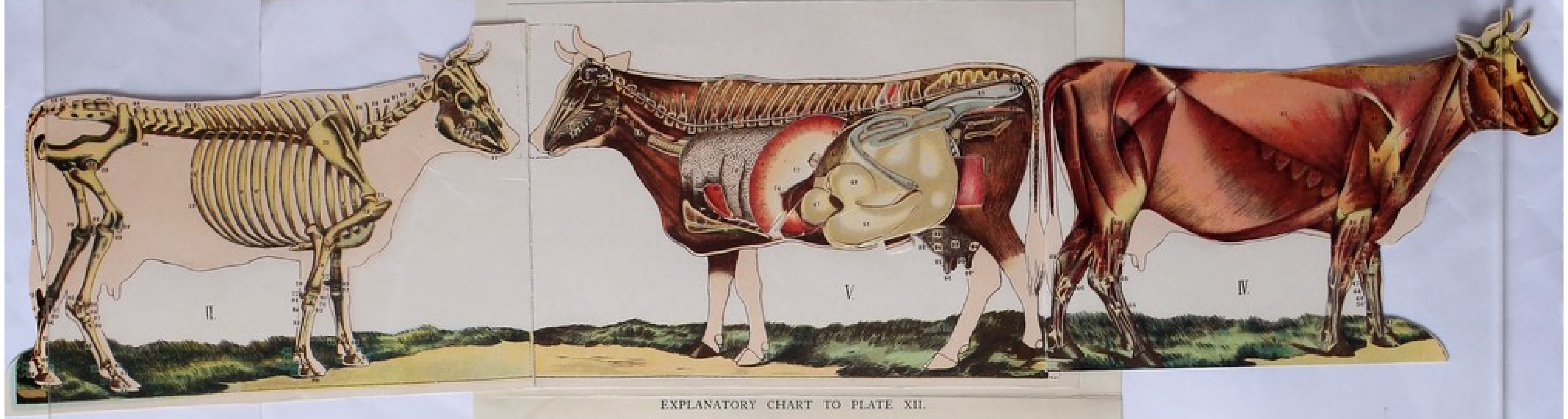
IV.—THE MUSCLES.

[illegible]

V.—THE BOWELS AND PARTIAL MEDIAN SECTION OF THE BODY.

1. Large brain (cerebrum).
2. Small brain (cerebellum).

[illegible]



EXPLANATORY CHART TO PLATE XII.

I.—DIVISION OF THE BODY OF CATTLE.

II.—THE SKELETON.

III.—BLOOD CIRCULATION.

IV.—THE MUSCLES.

V.—THE BOWELS AND PARTIAL MEDIAN SECTION OF THE BODY.

panniculous carnosus, a few inches from its posterior angle at the groin and the fascia intervening between this point and the anterior muscles of the thigh.

"*Subdorsal Glands*.—These will be found on each side of the aorta, from about the fifth to the last dorsal vertebræ. Most of these glands are frequently removed in dressing, but two or three will be generally found from the tenth to the thirteenth vertebræ.

"*Intercostal Glands*.—Situated between the ribs at their junction with the vertebræ. In health they are very small, probably not larger than a pea. In disease, however, they may be the size of a hazel-nut.

"*Suprasternal Glands*.—Situated between the costal cartilages of the first six ribs, under the triangularis sterni, on the course of the internal thoracic artery. In front of the thoracic side of the insertion of the diaphragm, across the ensiform cartilage, will be found a gland superficially placed.

"*Prepectoral Glands*.—This large group of glands will be found at the entrance of the chest, on the surface of the first rib, if not removed by the butcher. A deeper gland, however, will be always found in the fat immediately anterior to the first rib, and beneath the scalenus muscle, resting upon the posterior deep pectoral.

"*Brachial Glands*. — These glands cannot be conveniently examined unless the fore-quarter is divided longitudinally. They can, however, be exposed by the moving of a portion of a second rib, when they will be found in the fat beneath, resting on the teres major, near its insertion into the humerus.

"*Prescapular Glands*.—Found in the mass of fat immediately anterior to the shoulder-joint, under the mastoido-humeralis muscle.

"An examination of the lymphatic glands is extremely important in tracing the origin, course, and extent of disease; consequently, their noımal size, consistency, and colour should always be taken into account. There are very few diseases or conditions that render the carcass of any animal unfit for human food but what produce some abnormal changes in these glands.

"Sectioning the carcass in the case of cattle should be done as far as possible in a customary manner, as undue mutilation is undesirable, should any portion of the carcass be passed. Different districts have slightly different methods, and the butcher can generally be allowed to divide in his own way so long as it permits of the purposes of inspection.

"In Manchester the fore- and hind-quarters are separated by commencing at the junction of the first and second lumbar vertebræ, or the sixth joint from the sacrum. The muscular area exposed is not large, and only occasionally will it suffice for the investigator. The hind-quarters should next be cut by making a complete section through the muscles of the thigh, commencing about an inch or so from the ischio-pubic symphysis, sawing through the head of the thigh bone (femur), after which the knife is directed in a longitudinal manner through the muscles of the flank. This is a customary section in the trade, and it is most satisfactory for the examiner, inasmuch as it exposes to view a large muscular area, and one which is frequently the seat of abnormalities.

"The fore-quarters should be divided by a longitudinal incision down through the shoulder-joint in order to expose the thick muscles and the joint cavity. After this section it is easy to expose the brachial and prescapular lymphatic glands."

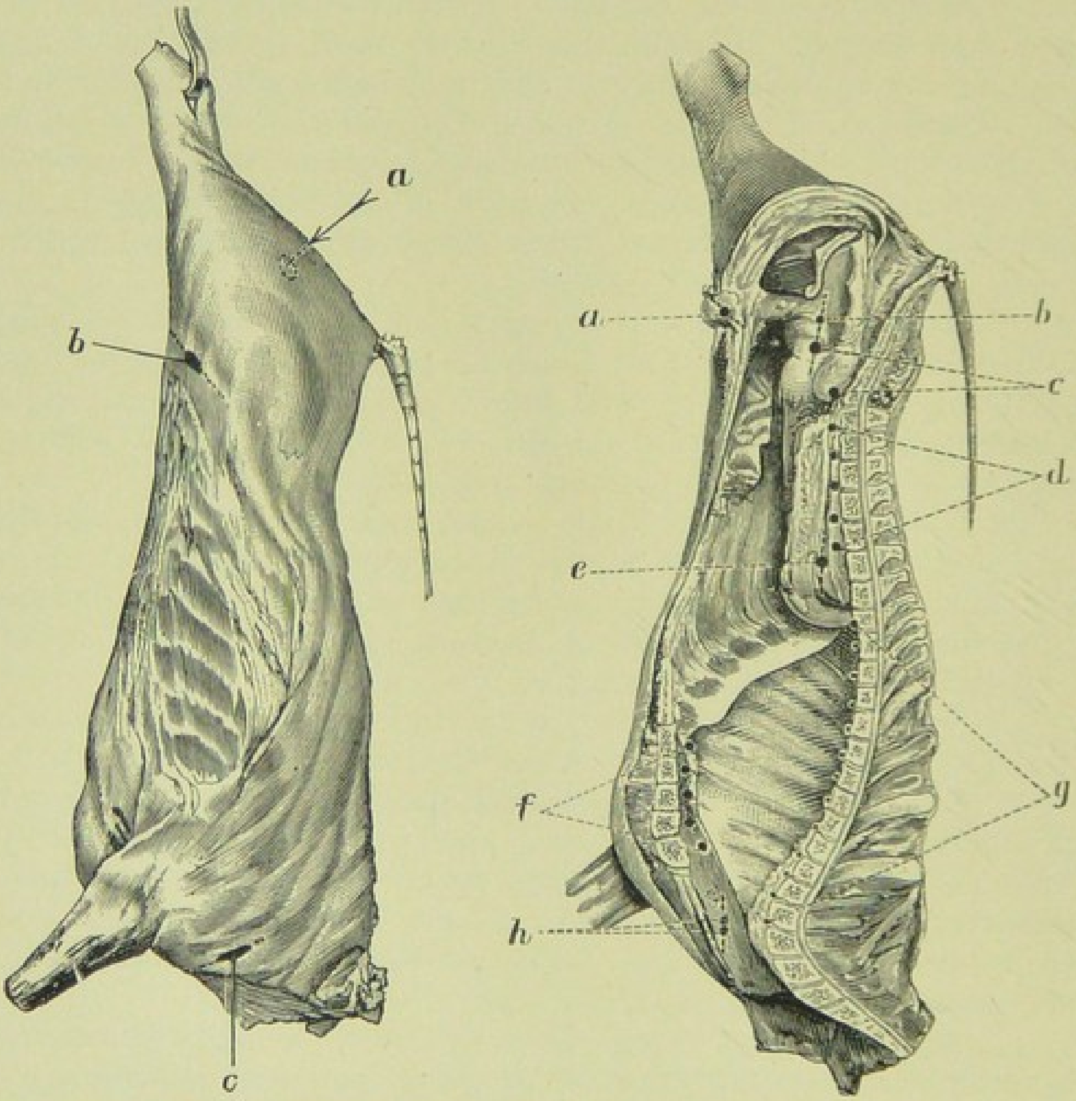


Fig. 3.—External and Internal Views of a Side of Beef.
(*Showing position of some glands.*)

a. Popliteal glands.
b. Kneefold glands.
c. Prescapular glands.

a. Superficial inguinal glands.
b. Deep inguinal glands (not always present, and variable in size).
c. Internal iliac glands.
d. Lumbar glands.
e. Renal glands.
f. Lymphatic glands of the inferior thoracic (chest) wall.
g. Glands of the superior thoracic wall.
h. Lower cervical glands.

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TUBERCULOSIS OF THE UDDER AND ITS SIGNIFICANCE.

"All are agreed," says Newsholme,[1] "that when there is tuberculosis of the udder the milk is found to be dangerously infectious, and so, likewise, are all products of such milk, as butter, skimmed milk, butter-milk, cheese." Jensen[2] takes the same view, and points out its significance in relation to public milk control. Newsholme refers to the report of the British Royal Commission of 1895 as showing the danger from this source. "The milk of cows with tuberculosis of the udder possesses a virulence which can only be described as extraordinary" (par. 61).

It is also ominous that ". . . . the spread of tubercle in the udder goes on with most alarming rapidity" (par. 62). Sims Woodhead remarks, "I have noticed on several occasions, during the intervals between fortnightly inspections carried on along with a veterinary surgeon, that the disease had become distinctly developed. It may be, of course, that the early evidence has been overlooked at the previous inspection, but whether this is the case or not, the spread of the disease was so rapid as to afford very good ground for alarm. The very absence of any definite sign in the earlier stage is one of the greatest dangers of this condition."

Bang[3] discusses the matter as follows: "It is evident that tubercle bacilli appear in the greatest number in milk when the udder itself is infected by tuberculosis. The milk secreted in such an udder contains enormous numbers of tubercle bacilli, and it is not too much to say that a cow suffering from this form of the disease daily distributes millions of live and virulent tubercle bacilli. It is, therefore, important to bear in mind the peculiar fact, to which I called attention twenty-four years ago, that the milk from a tuberculous udder retains for a long time, often for a month, its natural appearance. The danger of contagion is thereby highly increased, for the milker, as a rule, lets the milk from the sick gland run into the pail as long as it looks natural; many times, indeed, after it has commenced to look somewhat thin and fluffy. When the milk is watery and clotted, it will probably be milked on the floor, but in that case it contributes to the infection of the stable.

"Tuberculosis of the udder is, therefore, a very dangerous disseminator of contagion, and it is by no means a rare disease. In Denmark a good law has for ten years been in effect, that any cows suffering from tuberculosis of the udder must be killed and the owner indemnified by the State. This law is pretty well enforced, and we kill yearly about 700 cows suffering from this disease. All cases are, of course, not diagnosed, but I do not believe that there are more than 1,000 cases annually of this form of the disease in Denmark. As there are about 1,000,000 milch cows, this shows that one per

1. The Prevention of Tuberculosis, p. 142.
2. Milk Hygiene, p. 71.
3. 6th I. C. on T., Special Vol., p. 214.

thousand of our cows are annually attacked by tuberculosis of the udder.

"Statistics published by the East Prussian 'Heerbuchgesellschaft,' a society representing large farms on which tuberculosis is combated by the method introduced by Ostertag, shows somewhat higher figures. There, tuberculosis of the udder was found in 2·5 per 1,000 of all the clinically examined cows, but the data are chiefly gathered from larger herds in which tuberculosis is pretty widely extended.

"It is not only when tuberculosis in a perceptible degree has attacked the udder that the milk can contain tubercle bacilli. These can be secreted also through the apparently normal udders. But it is hard to believe that this will occur except in cases where the cow suffers from a very advanced stage of tuberculosis, as it can happen only when the bacilli circulate in the blood."

Schroeder[1] admits that the observations of the Experiment Station of the Bureau of Animal Industry confirm this latter view ; yet another member of the Bureau, Mohler,[2] quotes the experiment of the British Royal Commission and that of Titze as follow :—

"The ease with which tubercle bacilli may be eliminated by the udder was strikingly illustrated by an experiment conducted by the British Royal Commission, in which a cow, injected with human tubercle bacilli under the skin of the shoulder, began excreting tubercle bacilli from the mammary gland seven days later, and continued to do so until its death from generalised tuberculosis thirty days after inoculation. Furthermore, Titze, of the Kaiserliche Gesundheitsamte, proved that human tubercle bacilli when injected into the jugular vein of milch cows may be excreted with the milk. In his first experiment the excretion of the bacilli began in the third week and continued until the one hundred and forty-fourth day. In a subsequent test tubercle bacilli began to be excreted after twenty-four hours, but no tubercle bacilli could be found after ninety-nine days. In both these cows only the milk from the left hind quarter proved to be infectious."

PREVALENCE OF UDDER TUBERCULOSIS.

According to Jensen[3] "There are no reliable statistics to show the prevalence of udder tuberculosis of the cow in Denmark ; but the operation of the law requiring the compulsory slaughter of cows with tuberculosis of the udder shows it to be of quite common occurrence. For this cause 407 cows were killed during 1898-9, 592 in 1899-1900, 610 the following year, and 584 in 1901-02. From Saxony it is reported that from 1888 to 1897, 1·1 to 3·7 per cent. of the tuberculous cows killed in the slaughter-houses were affected with udder tuberculosis, and in the whole German Empire in 1888-9 the percentage of udder tuberculosis among the tuberculous cows killed was 1·62.

1. P. H. and M. H. S., Bull. 56, p. 533.
2. 25th Annual Rept. B. A. I., p. 158.
3. Milk Hygiene, p. 72.

Ostertag rates the prevalence of udder tuberculosis at 4 per cent. of all tuberculous cows. Probably cows reacting to the tuberculin test are not to be understood among these, but only such as are found after slaughter, by superficial examination, to be tuberculous. The number of cows with udder tuberculosis is, without doubt, very great, and in connection with the control of milk one cannot rate the significance of this disease too highly."

Salmon[1] summarises the European statistics as showing "....from 1½ to 3 per cent. of the total number of cases" (of tuberculous animals), and further states that "Pearson, in the examination of 1,200 tuberculous cows in Pennsylvania, found the udder affected in 8·75 per cent. of the animals."

Professor John M'Fadyean,[2] in 1901, estimated that about 2 per cent. of the cows in the milking herds in this country were affected with udder tuberculosis.

In 1899 Delépine[3] came to the conclusion that about 3·7 per cent. of tuberculous cows were affected in the udder.

"This estimate," he says, [4]"was rather higher than those made at the time by three well-known veterinary authorities, but subsequent experience has shown me that even my estimate was barely high enough."

We shall see later (p. 97) that Delépine estimates that out of 28 tuberculous cows one is affected in the udder. M'Fadyean estimates (see p. 16) 30 per cent. of dairy cattle are tuberculous in this country. Taking these two estimates together, we arrive at practically 1 per cent. of the dairy cows of this country as suffering from udder tuberculosis.

Jensen[5] speaks of "....the frequency with which udder tuberculosis occurs," while the British Royal Commission[6] say it is comparatively common in cows.

Mr. John Kirby,[7] a recognised authority on dairying in this country, takes strong exception to this latter term—"comparatively common"—and quotes the reports of the Medical Officers of Edinburgh, Lanark, and London County Councils, which show quite a small number of cases of udder tuberculosis.

While the term "comparatively common" is somewhat indefinite and debatable, it is to be noted that the cases of udder disease detected by the above-mentioned authorities cannot be taken as showing the total extent of the disease among the cows examined, by reason of the method employed in its detection, namely, clinical examination. Undoubtedly, animal inoculations were employed to

1. B. A. I., Bull. 38, p. 32.
2. Trans. B. C. on T., 1901, Vol. 1, p. 84.
3. Veterinarian, London, 1889, 72, pp. 453, 528, 683.
4. Pro. Roy. Soc. Med., Vol. 3, No. 7, Epidemiological Sect., p. 219, May, 1910.
5. Milk Hygiene, p. 74.
6. Third Interim Rept., 1909, p. 5.
7. Journal of the British Dairy Farmers' Assoc., Vol. 24, pp. 51-62.

determine the infectivity of the milk, but the samples treated in this way were from cows which, in the first instance, were suspected on palpation[1] by the veterinarians.

We shall see that this method cannot be relied upon to detect tuberculosis of the udder, and, in fact, the Medical Officer of Lanark, in his 17th Annual Report, states that the clinical method does not detect one-thirtieth part of the tuberculous udders (see p. 93).

There are at least four forms of tubercular udder infection—

First.—Tuberculosis of the lymphatic glands at the top (or base, as it really is) of the udder, and these glands, when enlarged, can easily be felt just in the fork between the hind legs and at the top of the udder. This spot must always be carefully examined, remembering, however, that sometimes this condition is due to the ray fungus in Actinomycosis (see p. 409).

Second.—A diffuse, indefinable, slowly-increasing enlargement, accompanied by slight hardening of one, or perhaps two, of the quarters (frequently succeeding an attack of mastitis or garget), and often, in the first stages, attended by an *increase* in the quantity of milk from the affected quarter or quarters; and this milk teems with tubercle bacilli. There is no fever or sign of illness. This form of tuberculosis is by far the most dangerous.

Third.—The formation of one or more nodules or lumps of varying size in the substance of the quarter; these are hard and irregular in shape, and may either break through the skin and form tuberculous ulcers, or they may break internally and their contents be emptied into the milk ducts.

Fourth.—Small tuberculous nodules may form in the mucous lining of the milk tubes (in the same way as they do in the lining of the bowels), and these may break down and their bacillary contents be mixed with the milk.

DETECTION OF UDDER TUBERCULOSIS.

"Tuberculosis of the udder can be detected with great accuracy," says Delépine,[2] "by a combination of veterinary inspection of the cows and of bacteriological examination of milk obtained from udders showing signs of disease, more especially enlargement and induration. It is, unfortunately, impossible for the most experienced veterinary surgeon to distinguish, by inspection and palpation, tuberculous mastitis from all other forms of mastitis. It is also practically impossible for the veterinary surgeon, unaided, to discover by ordinary inspection early tuberculous lesions of the udder."

Unreliability of clinical examination

In judging of the reliability of unaided clinical examination one must approach in two directions. First, what proportion of the udders diagnosed as tuberculous on palpation and inspection prove

1. "Palpation"—the act of feeling.
2. 28th Annual Rept. L. G. B., 1908-9, Suppl., p. 412.

to be actually tuberculous? Second, how many of the udders judged to be healthy on physical examination are really healthy? In other words how often does the method lead the veterinarian to misjudge the healthy udder, and how often does the diseased udder escape detection?

It would be difficult to find a better example under the first heading than that afforded by the work of the Manchester Health Authorities. Delépine[1] says "....that *not more than one-third* of the udders which on inspection appeared to be possibly affected with tuberculosis, were on bacteriological examination proved to be actually tuberculous."

This work applies to some 700 udders, and, considering the experience and ability of the veterinarians concerned, must be accepted as a reliable criterion.

We are unable to point to so extensive an example under the second heading. This is owing to the labour and time required in determining by histological and bacteriological methods that an udder is certainly free from disease. The difficulty of proving a negative is not confined to histological work. Histology, we may explain, is the science that deals with the structure and nature of the cells of which tissues are composed.

Histology

The different elements composing the cells possess peculiar properties in relation to dyes, which enable one, with the help of the microscope and other delicate instruments, such as the microtome, which is used for cutting extremely thin slices—thinner than tissue paper—which can be seen through, to determine much in the way of detecting diseased or abnormal conditions.

Diffuse tuberculosis of udder

Instances are fairly common in the literature of the subject, however, showing that tubercular lesions in their early stages may not be particularly easy to find when one has the udder on the dissecting table,[2] and it will be readily understood that their detection in the living animal is still more difficult. This is notably the case when the tubercular lesion is of the diffuse type, in which the disease is disseminated practically throughout the whole organ and does not manifest itself in hardened areas (induration) for two or three weeks, during which time the disease may be in active progress, accompanied by virulent infection of the milk.

Delépine[3] agrees that "When the udder is diseased certain of its parts may be enlarged or indurated, and these changes can usually be recognised by inspection and palpation *when the udder is empty*."

Experimen evidence

Salmon[4] admits that "It requires a very long and careful examination to determine positively that the udder is free from the disease," and proceeds to cite that "Numerous investigations have also shown that milk may contain tubercle bacilli when there are no appreciable

1. 38th Annual Rept. L. G. B., 1908-9, Suppl., p. 413 footnote.
2. See Jensen, Milk Hygiene, p. 73.
3. 38th Annual Rept. L. G. B., Suppl., p. 350.
4. B. A. I., Bull. No. 38, p. 32.

signs of tubercular disease in the udder. A few of the more striking of these may be mentioned. Bang tested the milk of 21 tuberculous cows with normal udders by inoculating 48 rabbits. Two, or 9·5 per cent., of these cows transmitted the disease. Later he injected 40 guinea-pigs with milk from 28 cows affected with generalised tuberculosis, and showed that virulent milk was being secreted by four of these animals, three of which, on *post-mortem* examination, were found to have lesions in the udder. By intra-abdominal inoculations of 28 guinea-pigs with the milk of 14 tuberculous cows he found that three of the latter were excreting tubercle bacilli in their milk. The summary of these experiments shows that of 63 cows nine gave virulent milk, and of this number three had tuberculous udders, leaving 9·5 per cent. of the cows with normal udders producing infectious milk.

" Ravenel experimented with five cows, which reacted to tuberculin but showed no physical signs of tuberculosis. The udders in every case were free from disease, so far as a careful inspection could reveal. The *post-mortem* examination of these cows confirmed the diagnosis made during life. He inoculated guinea-pigs with a single dose, averaging 10 c.c.[1] of milk from these cows. In the first series of experiments four out of 31 guinea-pigs, or 12·9 per cent., became tuberculous. In the second series of experiments five out of 24 guinea-pigs contracted tuberculosis, a percentage of 20·8. In the third series, in which the milk of a single cow was employed, one guinea-pig out of eight became tuberculous, or 12·5 per cent. In these three series of experiments 10 guinea-pigs out of 63, or 15·8 per cent., became infected by a single dose of milk from these cows, which apparently had no disease of the udder.

1. The quantity used by Ravenel in the above instance seems rather excessive in comparison with the quantities used by other workers, as shown in the following table :—

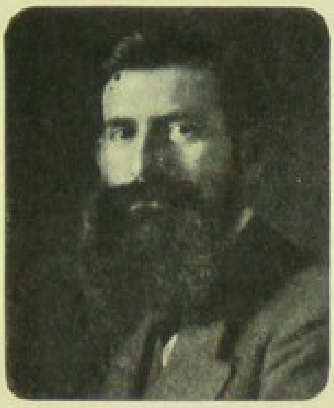
Experimenter.	Animal.	Quantity.	Method.
F. Gebhardt ..	Guinea-pigs	2·5 c.c. (1st series)	Intraperitoneally.
F. Gebhardt ..	,,	2 c.c. (2nd series)	,,
F. Gebhardt ..	,,	1 c.c. (3rd series)	Subcutaneously.
B. Bang ..	Rabbits	1 or 2 c.c.	Intraperitoneally.
St. Friis.. ..	,,	5 c.c.	,,
E. C. Schroeder	Guinea-pigs	5 c.c.	,,
A. Buege ..	,,	5 c.c.	,,
A. Massone ..	,,	5 to 6 c.c.	,,
Ott	,,	5 c.c.	,,
Petri	,,	3 and 5 c.c.	—
Ostertag.. ..	,,	10 c.c.	—

See P. H. and M. H. S., Bull. 56, pp. 168-78.

Delépine believes that not more than 2 c.c. should be used, otherwise complications may arise (38th Annual Rept. L. G. B., Suppl., 1908-9, p. 348).

"Rabinowitsch and Kempner succeeded in producing tuberculosis in guinea-pigs with the milk of 10 out of 15 tuberculous cows, or 66·6 per cent. Two of these cows were later found to have tuberculous udders, three showed advanced generalised tuberculosis, while the

DR. LYDIA RABINOWITSCH
(Madam Kempner)
Pathological Institute, Berlin University.



DR. KEMPNER.
Bacteriologist.

remaining five animals were but slightly affected. The writers conclude that milk from cows with incipient tuberculosis, but without disease of the udder, may contain tubercle bacilli; also that in latent forms of tuberculosis the milk may prove infectious, although the cow may not present any clinical symptoms of tuberculosis; and, therefore, that milk from all cows reacting to tuberculin should be considered as at least suspicious. It is believed by Adami that the cells of an actively secreting mammary gland of a cow can take up and discharge the tubercle bacilli without the animal showing any lesion of the lacteal tract."

"Adami and Martin[1] examined the milk of 10 cows, and when these were killed the udders were subjected to microscopic examination with negative results. In the milk of six (60 per cent.) of these cows tubercle bacilli were observed by the aid of the microscope. The milk from the cow showing the greatest number of bacilli was inoculated into two guinea-pigs, and both died as a result of the infection. Twenty-nine guinea-pigs and 26 rabbits were inoculated with varying quantities of milk and one calf was fed for five months, but only two guinea-pigs died of tuberculosis.

"Gehrman and Evans found tubercle bacilli in the milk of 15 out of 41 cows with sound udders, or 36·6 per cent. Guinea-pigs inoculated with milk from 10 of these cows died of tuberculosis (24·3 per cent.). Their final showing is that 16 of the cows, or 39 per cent., at one time or another gave milk containing tubercle bacilli.

1. Quoted by Salmon, B. A. I., Bull. 38, p. 33.

"The milk of 56 reacting cows which showed no signs of disease of the udder was carefully tested in various ways by Mohler and Nörgaard. One or more of the guinea-pigs fed with milk from nine different cows out of this lot succumbed to typical tuberculosis; that is, the milk of 16·07 per cent. of the 56 reacting cows was found to be pathogenic to guinea-pigs when fed to them.

"Of the experimental animals inoculated intra-abdominally in the first series, at least one guinea-pig died of tuberculosis in each of six different instances, showing that the milk of 10·9 per cent. of the 55 reacting cows in this experiment was fatal to guinea-pigs. In the second series of intra-abdominal injections, the milk from seven individual cows out of 45 examined, or 15·5 per cent., was demonstrated to possess virulent tubercle bacilli. By uniting these inoculation results, it is found that 11 out of 55 cows, or 20 per cent., secreted milk which transmitted tuberculosis to one or more experimental animals when injected into the peritoneal cavity.

"The combined results of the ingestion and inoculation experiments showed that the milk of 12 out of 56 reacting cows, or 21·4 per cent., at one time or another during the experiment contained virulent tubercle bacilli.

Histological methods not infallible

"Specimens of the mammary glands from all the cows yielding this virulent milk were brought to the laboratory, and histological examination was made of them without finding any indication of tuberculosis. With one of these cows positive results were obtained in all of the tests—that is, by ingestion, by inoculation, and by microscopic examination of the sediment of the milk and cream—although but seven of the ten experimental animals fed and inoculated with the milk of this cow became tubercular. It was evidently a case in which the milk was seriously contaminated. Special attention was given to the examination of the udder of this cow, and numerous serial sections were examined, with entirely negative results.

"The results of these careful experiments prove that the milk from a considerable proportion of reacting cows contains the tubercle bacillus, and is capable of producing tuberculosis in animals which consume it. The proportion of cows which yield such infected milk is much greater than the proportion which show tuberculosis of the udder. Whether the milk in these cases was actually infected within the udder, or whether it became contaminated at the time it was drawn, makes little practical difference. Every precaution was taken to prevent such contamination after the milk left the mammary gland, and if the bacilli floating in the air of the infected premises, or dropping from the coats of the animals, infected the milk, in spite of the precautions that were taken, similar infection would certainly occur in ordinary dairy operations. It must be admitted, therefore, that the milk from tuberculous cows is often infected and dangerous when, so far as can be ascertained, the udder is in a normal condition."

Ward[1] confirms this in stating that "....the indurated areas in udders affected with mammitis raise insurmountable difficulties in the differential diagnosis by physical signs."

Such a case is described by Savage (see Section III.).

Park[2] says "....it is never possible to state that a tuberculous cow has no udder tuberculosis."

As pointed out by Webb, Williams, and Barber,[3] "The work of Lannelongue[4] suggests that microscopical examination is not sufficient to show absence of tuberculosis, and that different tissues should be injected into fresh guinea-pigs."

Histological methods

The Third Interim Report of the British Royal Commission on Tuberculosis[5] states that "The milk of two cows, B and C, caused, though not invariably, tuberculosis in guinea-pigs inoculated with relatively small doses. The milk was withdrawn from the udder by catheterisation, and *post-mortem* examination of the udders revealed no macroscopic (naked eye) evidence of tuberculosis. Small pieces were examined histologically by Dr. Eastwood, and were found to be normal, but it is of course impossible positively to exclude microscopical lesions.

"The milk of a third cow, F, caused severe tuberculosis in every guinea-pig which lived a sufficient period of time after inoculation. The udder, except for four small nodules in the left hind-quarter, was normal to the naked eye: the animal was very ill at the time the milk was collected."

When one grasps the full significance of the statement of the Royal Commissioners, that it is impossible to positively exclude microscopical lesions, the hopelessness of clinical examination as a conclusive diagnostic method, in cases where lesions cannot be found, becomes apparent. The microscopical examination of an udder means that it has to be cut into slices so thin that they can be seen through. Special instruments and preparation of the tissue are necessary for this. Say the slices are cut an inch square (in practice one uses much smaller pieces). Each one has then to be carefully dyed by a differential staining method, so that the bacilli are coloured red and the remaining parts blue. When properly mounted on thin glass slides, each point has to be magnified under the microscope about a million times, so that a square inch becomes a million square inches, and this area has to be searched with great care to find bacilli stained red. When the slices of the whole udder have been dealt with in this way, the histologist may be in a position to say that he has not found the bacilli, but he will hesitate to affirm they are not there. Cases are

1. Pure Milk and the Public Health, p. 69.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 160.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 207.
4. Influences modificatrices de l'evolution Tuberculeuse. Paris, 1908.
5. P. 14 of Report, 1909.

not altogether rare in which the presence of the organisms was proved by inoculation when the histologist had failed to find them, hence the statement of our Royal Commissioners. We may safely conclude, therefore, that to report an udder free from lesions when the milk from it has been proved tuberculous is one that a scientist may well hesitate over. How much more difficult to be certain with the living udder, and how necessary to employ any other means as safeguard to ensure the health of the organ—not only the organ, but the whole animal. Hence the insistence of so many authorities that there is only one way —the tuberculin test.

Delépine's observations

Delépine[1] says that "For some time after the onset of tuberculosis in the udder, the lesions are so slight that even an experienced veterinary surgeon may have great difficulty in deciding whether the udder is diseased or not. From an administrative point of view this difficulty is most inconvenient, and we have, therefore, paid special attention to it. I need only refer to four cases inspected by Mr. Lloyd. The mixed milk supplied by three farms having been found tuberculous, these three farms were inspected, but no tuberculous udder could be discovered; the mixed milk of these three farms was again tested bacteriologically, and still found to be tuberculous. Mr. Lloyd inspected again these farms, and after a very lengthy examination he discovered in each a cow showing slight signs of disease of the udder, *but in none were the symptoms at all typical of tuberculosis.* A sample of milk was taken from each of these cows, and each of the three samples produced tuberculosis in the experimental animals.

"In another case Mr. Lloyd took a sample of milk from a cow suffering from advanced pulmonary tuberculosis, the udder appearing to be free from disease at the time. I found that the milk contained tubercle bacilli. Mr. Lloyd visited the same farm five weeks after his first visit and detected slight induration of one of the hind quarters of the udder. Two weeks later he examined the cow again and found the induration more marked. He then took a separate sample of milk from each teat, and sent those samples to me. Of these four samples only one produced tuberculosis, and this was the sample taken from the diseased quarter."

"It has been....established," says Mohler,[2] "that in advanced generalised tuberculosis, the udder may secrete tubercle bacilli without showing any indication of being affected. Careful experiments, performed by trained and eminently responsible investigators, have also demonstrated beyond reasonable doubt that tubercle bacilli at certain times may be present in the milk of cows affected with tuberculosis to such a degree that the disease can be detected only by the tuberculin test, so that in a herd of cows in the various stages

1. 38th Annual Rept. L. G. B., Suppl., p. 355.
2. P. H. and M. H. S., Bull. No. 56, p. 505.

of tuberculosis it is to be expected that some of them will secrete tuberculous milk, which, when mixed with other cows' milk, makes the entire product dangerous."

Mohler's conclusions

Mohler[1] sums up the views represented in the foregoing in the following eight conclusions, and quotes a number of distinguished authorities supporting them.

"(1) The tubercle bacillus may be demonstrated in milk from tuberculous cows when the udders show no perceptible evidence of the disease, either macroscopically or microscopically.

"(2) The bacillus of tuberculosis may be excreted from such an udder in sufficient numbers to produce infection in experimental animals, both by ingestion and inoculation.

"(3) That in cows suffering from tuberculosis the udder may, therefore, become infected at any moment.

"(4) The presence of the tubercle bacillus in the milk of tuberculous cows is not constant, but varies from day to day.

"(5) Cows secreting virulent milk may be affected with tuberculosis to a degree that can be detected only by the tuberculin test.

"(6) The physical examination or general appearance of the cow cannot foretell the infectiveness of the milk.

"(7) The milk of all cows which have reacted to the tuberculin test should be considered as suspicious, and should be subjected to sterilisation before using.

"(8) Still better, tuberculous cows should not be used for general dairy purposes."

Open tuberculosis

The position taken up by Rabinowitsch, that the milk of all tubercular animals contains tubercle bacilli, is, however, entirely rejected by Bang,[2] who says that it is not so.[3] "If the animal is not affected with open tuberculosis," Bang continues, "there are no tubercle bacilli in either the milk or in the fæces. When some of the lesions open, and the bacilli enter into the lymph or blood circulation, then the bacilli may be temporarily present in the milk or fæces."

Heymann[4] stated, however, and Schroeder agreed, "....that we have practically no means of distinguishing between open and closed tuberculosis."

1. B. A. I., Bull. 44, 1903.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 610. Confirmation that tubercle bacilli injected either under the skin or into the blood stream of bovines may be arrested in the udders and develop there, even in the immature udders of young calves, has been shown by the British Royal Commission (see Final Rept., p. 28, and p. 82 of this book). In the Memorandum to Final Rept. of Royal Commission, p. 47, it is stated: "Of the eleven experiments performed nine showed that the normal mammary tissue will permit of the escape of tubercle bacilli into the milk after the bacilli have obtained access to the blood stream in sufficient quantities."
3. "....similarly," according to Prof. Sir John M'Fadyean, "the bacilli escape from the genital passages of the cow only when there is tuberculous disease of the womb" (Jour. R. A. S. E., 1910, p. 38).
4. 6th I. C. on T., Vol. 4, pt. 2, p. 612.

Taken in conjunction with Professor Bang's earlier work (see p. 101), quoted by Anderson, the admission that in closed tuberculosis some lesions may temporarily open, and that all "children's milk" sold in Copenhagen is drawn from non-tuberculous cows, the position, considered as a discussion of *possibilities*, hardly seems materially altered, though, as we shall shortly see, it appears quite differently in weighing the *probabilities*.

Writing in 1908 regarding tubercle bacilli having been found in milk when udder disease was absent, Newsholme[1] stated that "These results have failed to be substantiated." Newsholme[2] quotes the work of Ostertag, who "....examined 77 such cows without finding tubercle bacilli in the milk after testing it microscopically, by inoculation and by prolonged feeding experiments.

Infection not from the udder

"Ascher, M'Weeney, and Strenström obtained like results. The latter concluded that tubercle bacilli found in the milk by observers obtaining different results must have gained access to it during milking. This may have been derived from tuberculous milkers; but Ebers regards the very common fouling of the milk with particles of cow-dung as the source of tubercle bacilli.

"Tuberculous cows, after coughing, commonly swallow their expectoration, which would subsequently appear in the fæces" (see Schroeder's work, p. 105).

"The detailed results of the East Prussian Herdbook Society are interesting in this connection. Samples of milk were taken from the total milk of 1,596 herds, and tubercle bacilli were found in 97 samples. In 59 of these tuberculous udders were discovered, and in other instances there was reason to believe that contamination of the milk after leaving the animal had occurred. The above experiment represented the milk of about 20,000 cows, and it may be assumed in accordance with average experience that 6,000 to 7,000 of these were tuberculous; and yet, in 1,449 out of 1,596 herds no tubercle bacilli were found in the milk. The evidence that contamination of the milk is most often due to udder disease is very strong, though contamination by cows' dung or from milkers also occurs, and cannot be left out of count."

M'Fadyean[3] says ".... there is ample evidence to justify the assertion that, as a rule, the milk is not dangerous until the udder itself becomes diseased. The experiments pointing to an opposite conclusion form only a small minority, and the results obtained in most of them were probably due to carelessness on the part of the experimenter. In a few of the cases in which the milk of an apparently healthy udder was found to be infective, it is probable that the gland tissue was in reality diseased, though not to an extent discoverable without microscopic examination."

1. The Prevention of Tuberculosis, p. 143.
2. The Prevention of Tuberculosis, p. 143.
3. Trans. B. C. on T., Vol. 1, p. 83.

Jensen[1] also confirms this view in stating that " It appears to be probable that an excretion of tubercle bacilli in the milk takes place only when lesions of tuberculosis are present in the udder tissue."

Nevertheless, cows ". . . . that appear to be perfectly sound may give tuberculous milk. . . . ."

An experiment of the Royal Commission[2] shows, however, that tuberculous milk may be yielded from an udder in which lesions cannot be discovered by any known method, and which the Commissioners, therefore, accept is free from disease.[3]

Dr. John T. Wilson,[4] County and District Medical Officer to the County of Lanark, points out that the total number of tubercular udders detected, during the previous four years, among 42,024 cows by experienced and qualified veterinary surgeons was only ·08 per cent. This low figure is attributed in great measure ". . . . to the difficulty experienced by veterinary surgeons in detecting it. If we compare these results in live animals," Wilson continues, " with the records obtained at public slaughter-houses, there is found to be a wide discrepancy. For example, at Bellshill Public Slaughter-house, where the superintendent has, during the last three years, kept a careful record of all the more important diseased conditions detected, including tubercular disease of the udder, the number of cows found to have suffered from tubercular disease of the udder averaged about 2·6 per cent. As by far the greater number of milk cows find their way into public slaughter-houses for human food, and only a small proportion go to a knackery or are buried, it is probable that 2·6 per cent. is about the proportion affected in live stock, and that, as veterinary surgeons become more expert in their examination and take more samples of milk, the number of tubercular udders detected in future inspections will increase, **but at present we may assume that less than one-thirtieth of the actual number can be detected."** **Wilson's observations**

There appears to be no escape from the conclusion that clinical examination alone cannot be relied upon for the detection of udder tuberculosis, and one is led to inquire how it *can* be reliably detected.

Inoculation of the milk into experimental animals is the most certain method.

As our system of free chemical analysis of milk for customers seems to have given so much satisfaction, and filled a want on account of the confidence cowkeepers feel they may safely repose in us, we thought its scope of usefulness might be extended to the important issue of examination for tubercle bacilli.

Experiments of this nature constitute vivisection, which is illegal except performed under licence from the Home Secretary.

1. Milk Hygiene, p. 73.
2. Final Rept., p. 27.
3. Final Rept., p. 28.
4. 17th Annual Rept. of the County and District Medical Officer, Lanarkshire, p. 23.

We applied early in 1909 for a licence. It was declined.[1]

Legal control necessary

That more knowledge is sadly needed among farmers on this important subject is shown by such experiences as Dr. Orr[2] recites.

"In one case a cow, giving at each milking three gallons of milk, which was mixed with the rest of the milk from the cowshed, was seen by the Inspectors to be very ill. The farmer had not stopped to consider the effect of this illness on the milk. On being spoken to by the Inspectors, the cow's condition being so evident, he consented to have her killed, when she was found to be extensively affected with tuberculosis. In another case a cow was found to be 'suffering from some condition of the udder, there being blood in the milk. The milk from the cow was allowed to stand to settle, and then it was poured in with the rest of the milk except the settlings.' Another striking case is worth recording. A cow was suspected, by those in charge, of being infected with tuberculosis, as it was very ill and had a cough, and it was considered advisable to isolate it from the rest in the cowshed. One quarter of her udder was enlarged, and the milk drawn from it was watery and tinged with blood. Despite the suspicion of tuberculous disease, the milk from the enlarged quarter was given to pigs, and that from the other three quarters was sold for human use in the raw condition. This cow, on being killed ten days later, was found to be extensively affected with tuberculosis."

Salmon[3] thus describes the method of inoculation—

Method of inoculation

"One cubic centimetre of milk, as withdrawn, is sufficient. The milk should be injected into the muscular substance of the inner and posterior surface of the hind limb. This is as reliable as intraperitoneal injection, which was formerly the most widely employed, and was regarded by Rabinowitsch as the most conclusive, while it has the advantage of being much speedier. The experimental animal can be killed for further examination as soon as the lymph glands near the point of inoculation appear firm, hard, painless, and enlarged to the size of a small pea. This often occurs within ten days of inoculation; but should the lymphatic glands not become diseased, the experimental animals are killed six weeks after inoculation. The discovery of tubercle bacilli in the enlarged lymph glands or internal organs confirms the diagnosis. Intramuscular injection obviates sources of error due to the pseudo-tuberculous changes which so often follow intraperitoneal injection of milk accidentally containing acid-fast pseudo-tubercle bacilli. The entrance of acid-fast bacilli (which, by the way, can usually be recognised as such on account of their shape) can be avoided if, before withdrawing the milk, the udder be washed with soap and water, cleansed with 50 per cent. alcohol, and rubbed dry with

1. We have, however, made favourable arrangements with a distinguished pathologist to test samples for our customers on the understanding that the information is for private use only, and will not be used in judicial proceedings.
2. Dr. Orr's Rept., p. 14.
3. B. A. I., Bull. No. 38, p. 45.

sterilised wadding. The first 10 c.c. at least of the milk should be thrown away. Finally, the intramuscular method has the great practical advantage over the intraperitoneal that much fewer experimental animals die from intercurrent diseases."

Detection of tubercle bacilli in milk by cultivating in the laboratory is quite useless for practical purposes.[1]

Microscopical detection.

Bang and Delépine have shown, however, that tubercle bacilli, if present in the secretion of a single cow, can usually be detected microscopically in the sediment obtained by centrifugalisation. This is highly important for rapid work, as it can be carried out in a few hours. Bang[2] tells us that when he fails to find the organisms in the milk of a suspicious udder, he examines the samples of the hardened tissue harpooned out of the udder. The instrument used for the purpose is shown in the illustration below.

Harpooning of udders

"Harpooning," says Salmon,[3] "necessitates casting the animal. By carefully disinfecting the skin and using sterilised instruments,

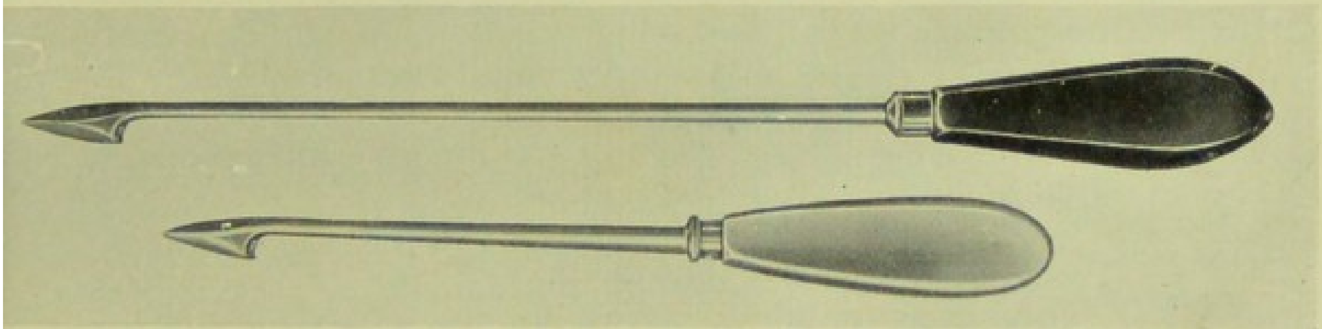


PHOTO.] FIG. 4.—Harpoons. (*Half size.*) [J. MURGATROYD.

the operation is rendered harmless even if repeated several times. The skin and the fascia of the udder are first divided, the suspected portion of the udder grasped with the hand, the harpoon introduced into the supposed diseased part, rotated slightly, and rapidly withdrawn. A small fragment of tissue is sufficient, provided a tubercle can be recognised by macroscopic or microscopic examination. Harpooning may be resorted to when inoculation has failed to confirm an otherwise strong suspicion of tuberculosis, or when the milk has ceased to be secreted and, therefore, cannot be employed." It is evident that harpooning is an operation that can only be resorted to by an expert

PROBABILITY OF UDDER TUBERCULOSIS AS THE CAUSE OF TUBERCULOUS MILK.

As a measure in the suppression of bovine tuberculosis, "Emphasis has been laid," says Ward,[4] "upon the value of detecting the tubercular udder, as if it were a very important factor in the contamination of milk. As a matter of fact, the development of tuberculosis in the udder to a degree that would attract attention

1. Jensen, Milk Hygiene, p. 86.
2. Private communication.
3. B. A. I., Bull. No. 38, p. 46.
4. Pure Milk and the Public Health, p. 69

is very rare." The masterly work of Delépine during the last fifteen years, however, shows that, in relation to wholesome milk supply, the tubercular udder just is the very important factor. "The tuberculous udder," he says,[1] "is now, as was always my opinion, rightly considered to be by far the most important source of tuberculous milk."

This view was advanced by the British Royal Commission of 1895,[2] as follows: "According to our experience, then, the condition required for ensuring to the milk of tuberculous cows the ability to produce tuberculosis in the consumers of their milk, is *tuberculous disease of the cow affecting the udder.* It should be noticed that this affection of the udder is not peculiar to tuberculosis in an advanced stage, but may be found also in mild cases."

Six years later, at the British Congress on Tuberculosis, M'Fadyean[3] maintained the same position. "....whatever danger attaches to milk comes mainly from the cows with tuberculosis of the udder, and the public health would be almost entirely safeguarded from this danger if we could exclude such animals from our dairies."

The outcome of the first eleven years of Delépine's[4] research showed that infection of milk supplied to Manchester was—

Certainly, or almost certainly, due to tuberculosis of the udder at ..	78·6 per cent. of the farms.
Probably due to tuberculosis of the udder at	16·0 ,, ,,
Possibly due to tuberculosis of the udder, or to other sources of infection, at	5·2 ,, ,,

"Although it is difficult to deny," says Delépine, "the possible danger of other sources of infection, it is clear that tuberculous infection of the milk is in a very high proportion of the cases due to tuberculosis of the udder." This is confirmed by the fact that [5]"After the elimination of these cows [cows with tuberculous udders] the milk of the farm almost invariably lost its infective properties."

It is also important to note that, with very few exceptions, the cows with tuberculous udders were old animals,[6] and [7]"....in the majority of cases suffering also from more or less advanced tuberculosis of other organs. I have personally examined *post-mortem,*" continues Delépine, "the organs of a great number of cows affected with tuberculous mastitis, and in only one case out of nearly 100 have I failed to discover tuberculous lesions of internal organs. In three more cases out of the same number, the internal lesions were limited; in the great majority of cases they were extensive. Out of more than

1. 38th Annual Rept. L. G. B., Suppl., p. 352.
2. Rept. of 1895 Royal Commission on Tuberculosis, p. 17.
3. Trans. B. C. on T. 1901, Vol. 1, p. 86.
4. 38th Annual Rept. L. G. B., Suppl., p. 412.
5. 38th Annual Rept. L. G. B., Suppl., p. 388.
6. 38th Annual Rept. L. G. B., Suppl., p. 410.
7. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 219.

300 cows suffering from tuberculosis of the udder, and examined by several veterinary surgeons, only four have been reported to me as having been free from any other tuberculous lesions. Primary tuberculosis of the cow's udder would, therefore, appear to be of rare occurrence.

Primary udder tuberculosis rare

"Tuberculous mastitis is not common in young cows. I estimate that about 90 per cent. of the animals suffering from this lesion are middle-aged or old cows, *i.e.* cows over four or five years of age."

Young cows seldom affected

Delépine[1] also draws the important inference "that the number of cows found affected with tuberculosis of the udder in a district may be taken as a rough index of the probable number of tuberculous cows in that district."

Seeing that tuberculous mastitis can, by bacteriological methods, be diagnosed with great accuracy without performing any operation on the animal, even the tuberculin test, Delépine's thesis would seem to simplify the process of dealing with extensive areas from an administrative point of view.

By the examination of samples taken at railway stations of a great city a deal of information can be derived regarding the incidence of bovine tuberculosis in the surrounding area. Delépine dealt with nearly 5,000 square miles, and tested 5,320 samples[2] of milk by inoculation over a period of fifteen years. "It may....be safely assumed," says Delépine,[3] "that for each cow affected with tuberculous mastitis there are, on an average, about 27 cows with tuberculous lesions of other organs."

Pathologists, veterinarians, and dairymen are agreed that the sale of milk from tuberculous udders should be stopped. M'Fadyean,[4] in 1901, included in this dictum "....cows that are obviously tuberculous in any part of the body, and it must be declared illegal," he added, "to keep such animals alive. There need be no hesitation in pressing for this reform, because the measures demanded are in the interests of the owners of the cattle, and would be advisable even if it were established that bovine tuberculosis is not transmissible to man. There is no dispute as to the danger of visibly tuberculous animals to others of their own species, and it is the very reverse of a hardship to the owner of such animals to insist on their being slaughtered." Eastwood[5] maintains that this course "....is imperative in the interests of agriculture."

The position established by Delépine that the tuberculous udder is the main source of infected milk has been ingeniously and courageously expanded by a prominent and erudite milk producer

1. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 220.
2. 38th Annual Rept. L. G. B., Suppl., p. 411. In the later Report of 1910 (see Note 1), the number is extended to 7,000 samples.
3. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 219
4. Trans. B. C. on T., Vol. 1, p. 87.
5. Dr. Eastwood's Rept., p. 78.

of Belfast—A. G. Wilson, Esq.[1] Hereunder we give a résumé of his thesis.

Economy necessary

Milk is the food of the poor man's child, therefore its cost should not be increased unnecessarily. If the removal of the clinically tuberculous cow removes the source of tubercular infection, why go to the great expense of rejecting all reacting cows from our dairies ?

Mr. Wilson has not yet received a satisfactory answer to his question, "Can a clinically healthy cow, reacting to the tuberculin test, fatally infect a human being ?"

In the absence of a positive answer sustained by proof, Wilson assumes the truth lies in a negative.

Proportion of human reacters

By comparing the result of tuberculin testing on three regiments of Austrian soldiers[2] and the testing of bovines (taken as 25 per cent. of reacters), Wilson concludes that the disease is twice as prevalent in men as it is in bovines.[3] It is assumed that the proportion of reacters among women would be the same as in males.

Seeing that we do not test the nursing mother with tuberculin, to determine her suitability to nurse her own child, neither should we impose the test on bovines which do not show clinical signs of the disease when their milk is needed for children.

It is conceded that, in the early stages of udder tuberculosis, the bacilli are present in small numbers before clinical signs are discoverable, but these are not only insufficient to produce infection, either in the child or in guinea-pigs (therefore, are not discoverable, which, of course, is quite reasonable seeing that a sufficiency of tubercle bacilli may be present in milk to effect immunisation, although insufficient to cause infection in a guinea-pig), but are positively beneficial, in immunising the child against tubercle bacilli which may reach it in dangerous numbers from other sources. Extending this view, if children are deprived of this "immuniser," we shall be compelled to find a substitute. Milk, it is claimed, is the only conceivable source of tubercle bacilli from which we can anticipate positively beneficial results—the only conceivable source of universal protection against an increase in the tubercular death-rate. This is in spite of the dictum that bacilli in the milk of healthy reacters is rarely or never discoverable ; in fact, the chance of their presence is infinitesimal.

Wilson goes into figures to show that the milk of healthy reacters is not infective by feeding, and discusses the importance of natural animal resistance and immunity to disease, noting the fact that nearly all human beings contract tuberculosis at some period in their lives

1. See The Ark (Belfast), March, 1910, p. 6.
2. See The Suppression of Tuberculosis (von Behring ; Trans. by Bolduan), p. 22.
3. Wilson also refers to the proportion of humans in whom tuberculous lesions are found on autopsy, and is, therefore, prepared to accept that in bovines the disease only attains to a quarter of the extent found in man. This is not a fair comparison, however. The figures cited in the text serve the purpose.

and the majority recover. Similarly with bovines. Some stress is laid on the opsonin content of raw milk. Human resistance to the disease, as evidenced by the large proportion of recoveries, has been developed by the immunising effect of small doses of tubercle bacilli, and is compared to the protective effect of a moderate amount of cold against the next unavoidable exposure to chill. A trifling number of tubercle bacilli in a person's anatomy is not necessarily to be feared, and while tubercle-free milk is necessary for invalids, and should be produced in special dairies, all we should demand for healthy beings is the exclusion of milk from clinically affected udders.

This is to be attained by a rigid enforcement of the Dairies and Cowsheds Order plus the exclusion of obviously tuberculous animals, which would be more effective than the expenditure of millions of money on tuberculin testing. It is explained that no effort is made to palliate careless dairymen who offer unsatisfactory excuses.

Outlying district farmers

The farmers of outlying districts are the worst offenders, which is due in great measure to the smallness of their herds, so that when a tubercular udder develops, the milk of the remaining cows is insufficient to dilute it to a safe point. This condition of things develops into the real source of danger by the iniquitous system of "swapping," and selling "tubercle broth," by dealers in the streets.

It is not forgotten that the ultimate goal is the entire extirpation of tuberculosis from man and beast, but in the case of the latter this is to be attained by improved sanitation.

In considering the economic question that the cost of milk should not be unduly increased for the poor, one has to face the fact that several large firms in Britain are actually supplying bottled milk from tuberculin-tested cows at only slightly increased prices, and are making money.

This movement, we suspect, will become increasingly difficult for the producer as the proportion of rejected cows increases ; but, at the same time, it will become increasingly obligatory under the pressure of competition.

Healthy reacter ! !

"*Apparently*" healthy reacter is the term used by Mr. Wilson near the beginning of his paper, but subsequently the word "apparently" is omitted. Although the intention appears to be to use the term "clinically healthy," or apparently healthy, it may be useful to remark that no pathologist or veterinarian would accept the term "healthy" when applied to a reacting animal. In fact, the American School of the Bureau of Animal Industry would denominate many of the healthy reacters as "apparently healthy but dangerously tuberculous animals."

One recognises, however, that most human beings are tuberculous at some period of their lives, yet, as White[1] remarks, while tuberculous "....continue working their lifetime and seem none the worse for it."

1. 6th I. C. on T., Vol. 1, pt. 2, p. 1005.

One also knows that [1]"Cows affected with tuberculosis may live, notwithstanding their diseased condition, so many years that their death, when it does come, may be attributed with some justice to the infirmities incident to old age."

Reacter a menace

Schroeder,[2] however, regards the cow, during this period, as "....a centre for the infection of other animals and a menace to public health."

Regarding Mr. Wilson's first question, "Can a clinically healthy cow, reacting to the tuberculin test, fatally infect a human being?" there can be no doubt that a considerable amount of evidence can be adduced in support of a reply in the negative. It seems probable, however, that the difficulty in securing a reply from responsible authorities lies in the fact that it compromises the discussion inasmuch as it does not sufficiently cover the question, but is inextricably bound up with more important issues. Thus Bang, as we shall see (p. 311), believes there is no danger from milk if the cow shows no clinical symptoms of the disease. This is surely an answer to Mr. Wilson's question; but it is to be noted that the professor immediately proceeded to explain that the healthy reacter of to-day may be actively infectious to-morrow—a risk which his own people in Copenhagen will not accept in the case of children's milk, which must be drawn from non-reacting cows.

The contention based upon the dilution of infective milk by the healthy milk of the other cows in the herd is more convincing. The experimental work of Alexander, Reichenbach and Bock, and Ostermann, which Wilson quotes in addition to the arguments of Heymnan and other eminent authorities, and which we shall recount later, undoubtedly establishes a strong position. The question resolves into a discussion of the danger to be apprehended from milk as a causative agent in human disease, which will be dealt with in the following pages.

The term "healthy reacter" may be accepted as synonymous with non-clinical reacting cow, which we have frequently referred to in these pages. That such cows may, and actually do, yield milk containing tubercle bacilli in sufficient numbers to produce the disease in experimental animals when injected is not denied by Wilson. It does not necessarily follow, however, that such milk will produce the disease when taken as food in the ordinary way by *healthy* human beings. Professor Dewar concedes this point (see p. 314). While we do not for a moment dispute this position, it may be useful in this place to collect some evidence showing that healthy reacters do actually yield such milk, after which we shall return to a discussion of Wilson's views.

That "healthy reacters" may yield tuberculous milk has been abundantly established (see Mohler, p. 91).

1. Schroeder, 25th Annual Rept. B. A. I., p. 128.
2. 25th Annual Rept. B. A. I., p. 128.

In addition to those instances already cited (see p. 86), we may mention M'Fadyean and Woodhead,[1] who found among 13 unaffected udders two yielded tuberculous milk.

H. C. Brnst[2] has ably discussed the question, "How far may a cow be tuberculous before her milk becomes dangerous as an article of food?" He examined the milk from reacting cows whose udders showed no signs of disease. By inoculation of rabbits he found in one case 23 per cent. of the samples tuberculous. By inoculation of guinea-pigs with similar milk he found 42·8 per cent. infected.

By feeding calves with similar milk, five out of twelve became tuberculous. Feeding pigs with similar milk, two out of five became tuberculous.

We have in another place referred to the work of Rabinowitsch and Kempner (p. 87). The extent of the lesions in one case throws light on the importance of the extent of disease and its determination. Of ten such cows yielding tuberculous milk, Anderson[3] summarises:

1 had pronounced udder tuberculosis;
1 ,, udder tuberculosis demonstrable only histologically;
3 ,, advanced tuberculosis, and gave histologically the picture of chronic interstitial inflammation of the udder;
1 ,, low-grade tuberculosis;
1 ,, râles on one examination, but none on the next two;
2 ,, no symptoms of tuberculosis;
1 ,, symptoms of beginning tuberculosis only on the second and third examinations.

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When does milk become dangerous?

Would it not be asking too much of a veterinarian to state when the milk of such animals becomes actually dangerous?

B. Bang[4] demonstrated that the milk of tuberculous cows without demonstrable udder lesions could contain tubercle bacilli. In later years Bang employed the method of harpooning the udders to discover tubercular tissue.

Hirschberger[5] also showed that tubercle bacilli occurred not only in milk from tuberculous udders, but also where the udders were sound, and where the cow was but slightly affected with tuberculosis.

" Lydia Rabinowitsch[6] examined the milk of eight Berlin dairies. This milk was designed especially for the use of children, was not

1. Intern. Cong. Hyg. and Demog., 1891, Sect. 2, p. 197; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 170.
2. Amer. Jour. Med. Sci., xcviii, 1890, p. 439; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 169.
3. P. H. and M. H. S., Bull. 56, p. 176.
4. Deut. Zeit. f. Tiermed., 11, 1884, p. 45; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 168.
5. Deut. Arch. f. klin. Med., 44, 1889, p. 400; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 168.
6. Deut. Med. Woch., 26, 1900, p. 416.

sterilised, and sold for 35 to 60 pfennig per litre (4½d. to 8d. per quart). In three of these dairies the cows were rigidly tuberculin tested. No tubercle bacilli were ever found in this milk. In the other five the cows were subjected to clinical oversight by veterinarians, but the tuberculin test was employed only now and then upon suspicious animals. In three of these five dairies the milk was found to contain tubercle bacilli. The percentage of specimens containing tubercle bacilli is not stated."[1]

Healthy reacter paradoxical

"When we think of animals afflicted with diseases," says Schroeder,[2] "we usually picture them to our minds as showing distinct variations in their appearance and demeanour from what we regard as healthy and normal. Disease and no symptoms is almost a contradiction, and this seeming contradiction and truly paradoxical condition is one of the important facts about tuberculous cattle."

Commenting on the fact that tuberculin testing is very searching, since it discovers cases in which the lesions are small and obscure, Mohler[3] says "It should also be borne in mind that such a small lesion to-day may break down and become widely disseminated in a relatively short period. Therefore, any cow affected with tuberculosis, even to a slight degree, must be considered as dangerous ; not only to the other animals in the herd, but also to the consumer of her products."

Delépine[4] concludes that "So long as the presence of tuberculous cows, and more specially of aged tuberculous cows, is tolerated in our herds, a certain amount of tuberculous infection of the milk supply is inevitable. The elimination of cows with tuberculous udders undoubtedly removes the most material and dangerous source of infection, *but it is only after the milk has become infectious* that these cows are detected.

"Preventive methods based upon the state of the milk or of the udder cannot give results equal in value, either from an agricultural or from a public health point of view, to those that could be obtained by methods having for object the *eradication of bovine tuberculosis*. The latter, though more costly at first, would yield more permanent benefits, and finally be less onerous."

"Keeping the source of infection constantly on the premises," as Noack[5] expresses it, is a great drawback to eradication.

Hess[6] believes that "Even the staunchest supporter of Koch would not care to have his children drink milk from a cow which he knew was excreting tubercle bacilli."

Schroeder (see p. 114) has shown that milk is frequently contaminated with tubercle bacilli voided in dung and thus inadvertently allowed to gain access.

1. Quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 177.
2. P. H. and M. H. S., Bull. 56, p. 535.
3. P. H. and M. H. S., Bull. 56, p. 512.
4. 38th Annual Rept. L. G. B., Suppl., p. 414.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 992.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 528.

It is to be borne in mind that Schroeder demonstrated the infectivity of the dung-contaminated milk by means of guinea-pig inoculations, and many people will coincide with Dr. John F. Anderson,[1] who objects to drink milk which is pathogenic for laboratory animals.

Although it must be conceded that, according to distinguished authorities, "....individuals, by heredity or by exposure to a low degree of infection, develop a corresponding degree of immunity,"[2] it must not be forgotten that, according to Williams,[3] "....one attack ....does not necessarily protect from a second one, but rather predisposes to it." **Immunity and Infection**

Newsholme[4] also states that "In some cases, doubtless, resistance is steadily and increasingly lowered by the reception of further doses of infective material."

Moreover, as we shall see later (p. 379), considerable differences exist in the natural resistance of different individuals. The process of immunising human beings by the employment of living bacteria is approached by pathologists with caution and extreme care.

As a palliative and temporary measure, the elimination of cows suffering from tubercular mastitis is manifestly a crying necessity. One might say that all intelligent dairymen accept this position. Delépine, as we have seen, lays great stress upon it. Dr. Nathan Raw, in his lecture at the Tuberculosis Exhibition, London, June 16th, 1909, made an eloquent appeal, and estimated the cost for Great Britain at about a quarter of a million pounds. It is to be remembered, however, that if the milking herds were cleared of tuberculous udders to-day, there would be another crop to-morrow. Moreover, the statutes already in force, although somewhat incomplete, empower the prohibition of the sale of milk from such cows, while it is only the large cities which enforce them after obtaining special powers to extend the procedure in the direction of invasion to trace the infected milk to its source.

Regarding the opsonin content of milk, the researches of Dr. Wm. J. Butler,[5] of Chicago, indicate that it is very small indeed. **Opsonin in milk**

There can be no doubt, however, that money spent in enforcing the Dairies and Cowsheds Order, and in eliminating cows with tuberculous udders, would give a better return than by tuberculin testing. As a preliminary step its advantages are obvious beyond question, as evidenced by the Rt.-Hon. John Burns' first Milk Bill.

Wilson's contentions regarding the outlying farmers are completely confirmed by the observations of the medical officers of large cities and other investigators, such as Delépine, Boyce, and Klein; while

1. P. H. and M. H. S., Bull. 56, p. 168.
2. See Bang, 6th I. C. on T., Special Vol., p. 210.
3. 6th I. C. on T., Special Vol., p. 128.
4. The Prevention of Tuberculosis, p. 312.
5. 6th I. C. on T., Vol. 2, p. 390.

the importance of being able to trace milk from consumer to cow is strongly urged by Eastwood.

Sanitation will not eradicate bovine tuberculosis

It is too much to expect that improved sanitary conditions will dry up the source of the tuberculous cow. As we shall see later, this cannot be attained without stamping out infection.

The reports of the dairy inspectors for Belfast tell rather a sorry tale, yet they have no tuberculous milk. One wonders if Mr. Wilson's thesis might not be expanded to account for the high prevalence of human tuberculosis in his country. Is it because they have no tuberculous milk to immunise the people ?

This possibility is contemplated by Guillemet, Rappin, Fortineau, and Paton[1] in relation to the children of tuberculous mothers whose milk was found to produce reaction when injected into guinea-pigs, also by Dr. Bruynoghe concerning the ingestion of dead tubercle bacilli in sterilised milk (see p. 170).

TUBERCULOSIS OF THE UTERUS.

According to Bang,[2] tuberculosis of the uterus is commoner than tuberculosis of the udder. "In East Prussia," he says, "the disease was found in 4 per 1,000 of the milch cows." In cases of advanced tuberculosis, the uterus becomes involved, according to Professor Sir John M'Fadyean[3], more frequently in cows than in any other species of animals. It is of significance to the cattle owner, not only by reason of the liability of contaminating the milk with the vaginal discharge, but also because the calves born will invariably be infected. Probably Deering[4] referred to a case of this kind when he stated that he had "....seen a calf eight weeks old as badly affected as any matured animal."

The British Royal Commissioners, experimenting with six naturally tuberculous cows, found that [5]"Tuberculosis was present in the uterus of each of the severely infected cows (three out of six), and the uterine discharge contained numerous tubercle bacilli."

Newsholme[6] quotes Cornet's[7] figures for the age distribution of tuberculosis among cattle in Saxony, where the inspection of meat is compulsory, as follows :—

Of 120,490	calves up to 6 weeks of age	3, or	0·002	per cent.
665	cattle from 6 weeks to 1 year	1 ,,	0·15	,,
6,328	,, ,, 1 to 3 years old	440 ,,	6·90	,,
13,307	,, ,, 3 ,, 6 ,,	1,285 ,,	9·70	,,
11,101	,, over 6 years old	1,881 ,,	16·90	,,

1. Compt. rend de la Soc. d. Biologie, July 13th, 1906.
2. 6th I. C. on T., Special Vol., p. 215.
3. Jour. R. A. S. E., 1910, p. 32.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 915.
5. Third Interim Rept., p. 14.
6. The Prevention of Tuberculosis, 1909, p. 184.
7. "Tuberculosis," in Nothangel's Ency. of Practical Medicine.

Newsholme concludes that "The most probable interpretation of the preceding facts is that post-natal infection is the usual source of tuberculosis, though ante-natal infection occasionally occurs, and it may be somewhat more frequent than is generally recognised."

INFECTION BY TUBERCULOUS DUNG.

Dr. E. C. Schroeder,[1] Superintendent of the Experimental Station at Bethesda, Md., of the United States Bureau of Animal Industry, arrives at the following conclusions:— Schroeder's conclusions

"(1) Tuberculous cows, wholly free from visible symptoms of tuberculosis, frequently[2] expel tubercle bacilli from their bodies per rectum.

"(2) Tubercle bacilli in the fæces of tuberculous cows are not dependent upon intestinal tuberculosis, but commonly have their origin in the lung.

"(3) Tubercle bacilli in the fæces of tuberculous cows are evenly distributed throughout the entire mass, and hence the amount of infected material in the environment of tuberculous cows is very large.

"(4) Tubercle bacilli in the fæces of tuberculous cattle are well separated and easily detached, hence when infected fæces get into milk, the bacilli are washed free from the particles of fæces and remain in the milk, as they are too small to be strained out of it.

"(5) Since the fæces of cattle are a common, almost universal, impurity in milk, the presence of tubercle bacilli in the fæces of tuberculous cows makes it practically impossible to obtain milk at all times free from tubercle bacilli, either from tuberculous cows or in the environment of tuberculous cattle.

"(6) As tubercle bacilli in milk are freely transferred to the cream separated from it, and as tubercle bacilli are transferred to butter in the manufacture of which it is used, we must conclude that the presence of tubercle bacilli in the fæces of tuberculous cows is an important cause for the frequent infection of all dairy products obtained from tuberculous cows or from cows exposed in the environment of tuberculous cattle.

"(7) As the interval of time that elapses between the production and use of milk, cream, and ice-cream is very short, and as tubercle bacilli in butter retain their virulence for long periods of time,[3] the presence of tubercle bacilli in the fæces of tuberculous cows signifies that, while we continue to use raw milk from tuberculous dairy herds, live, virulent tubercle bacilli will be distributed far and wide in a way that ensures their entrance into the bodies of persons of all ages."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 604.
2. In another place Schroeder says "....more commonly....than in other ways." (See P. H. and M. H. S., Bull. 56, p. 533.)
3. See p. 132.

The above led Schroeder to the demand for either milk obtained from non-tuberculous cows whose environment is also free from the infection, or Pasteurisation.

That the bacilli rise with the cream and are transferred to the butter was demonstrated by inoculation of guinea-pigs, which became infected.[1]

With reference to the illustrations accompanying his paper, Schroeder[2] says "....it is desirable that the reader should bear in mind that no special effort was made to obtain photographs from many different sources, so as to present exceptional conditions. All the photographs are those of animals that were among a total of about 50 tuberculous cattle received at the experiment station during the last three years, and among this total of 50 there were at least 25 animals that could well have been used to illustrate the excellent physical condition of dangerously tuberculous cattle, and about 40 that could have been used to illustrate simply the healthy, normal appearance of tuberculous cows."

By kind permission of the Surgeon-General of the United States Public Health and Marine Hospital Service, we reproduce in the following pages some of Schroeder's illustrations of the tuberculous cows referred to.

The experiments were conducted with 12 dairy cows in excellent condition and showing no visible symptoms of the disease, but found to react to tuberculin. These were kept under observation for about two years.

During the first two months microscopical examinations revealed that five, or $41\frac{2}{3}$ per cent., of the cows were intermittently expelling tubercle bacilli per rectum; 18 months later the number had increased to ten, or $83\frac{1}{3}$ per cent., that is, it had doubled, though the majority of the cows still retained their apparently good condition and showed no symptoms of tuberculosis.[3]

Hog Infection

"A number of hogs confined in a yard of about a half an acre area, into which the manure from a stable containing a herd of tuberculous cows was thrown, became affected with tuberculosis."

Extent of Cow Dung in Milk.—On examination of the centrifugalised deposit from ordinary market milk, Schroeder found that "....not more than one among 50 samples is found to be entirely free from particles of vegetable matter, identical in appearance with minute fragments of bovine fæces. Roughly estimated, the average amount of such contamination on the market milk examined was one part in 4,000; but some samples contained fully one part of cow dung to every 400 parts of milk."

In the discussion following the reading of Schroeder's paper, Professor Heymans and Drs. Bebee and Bitting disagreed with

1. 6th I. C. on T., Vol. 4, pt. 2, p. 603.
2. P. H. and M. H. S., Bull. 56, p. 536.
3. 6th I. C. on T., Vol. 4, pt. 2, pp. 599-600.

Schroeder. Heymans did not consider the evidence conclusive. Dr. Bebee[1] pointed out that Schroeder's results were in opposition to those of Bebee and Reynolds, who inoculated about 200 guinea-pigs with fæces from 46 tuberculous animals. "All of these animals were known to be tuberculous for two or three years before the guinea-pigs were injected. Of these animals, only one was found which excreted tubercle bacilli in the fæces."

Dr. Bitting claimed that "....if the danger is as great as that indicated by the reader [Schroeder] not one of the workers in creameries would escape the disease. But it has been proved by my investigations of many years along this line," continued Bitting, "that the disease is not more prevalent among those men than in any of the other classes." Dr. Schroeder explained this contention on the ground that dairy hands drink very little milk (see p. 50).

British Royal Commission confirm

Our British Royal Commission certainly confirm Schroeder, also Mohler and Washburn,[2] regarding the possibility of tubercle bacilli being coughed up from the lungs, swallowed, discharged in the fæces, and contaminating the milk (see p. 45).

One cow, D, is described in which the lesions were limited entirely to the thoracic organs (lungs, pericardium, and pleura), and yet its fæces produced tuberculosis when injected into guinea-pigs and rabbits,[3] while four other cows, out of the six experimented with, excreted living and virulent tubercle bacilli in their fæces. These four cows showed some tuberculosis of the alimentary tract.

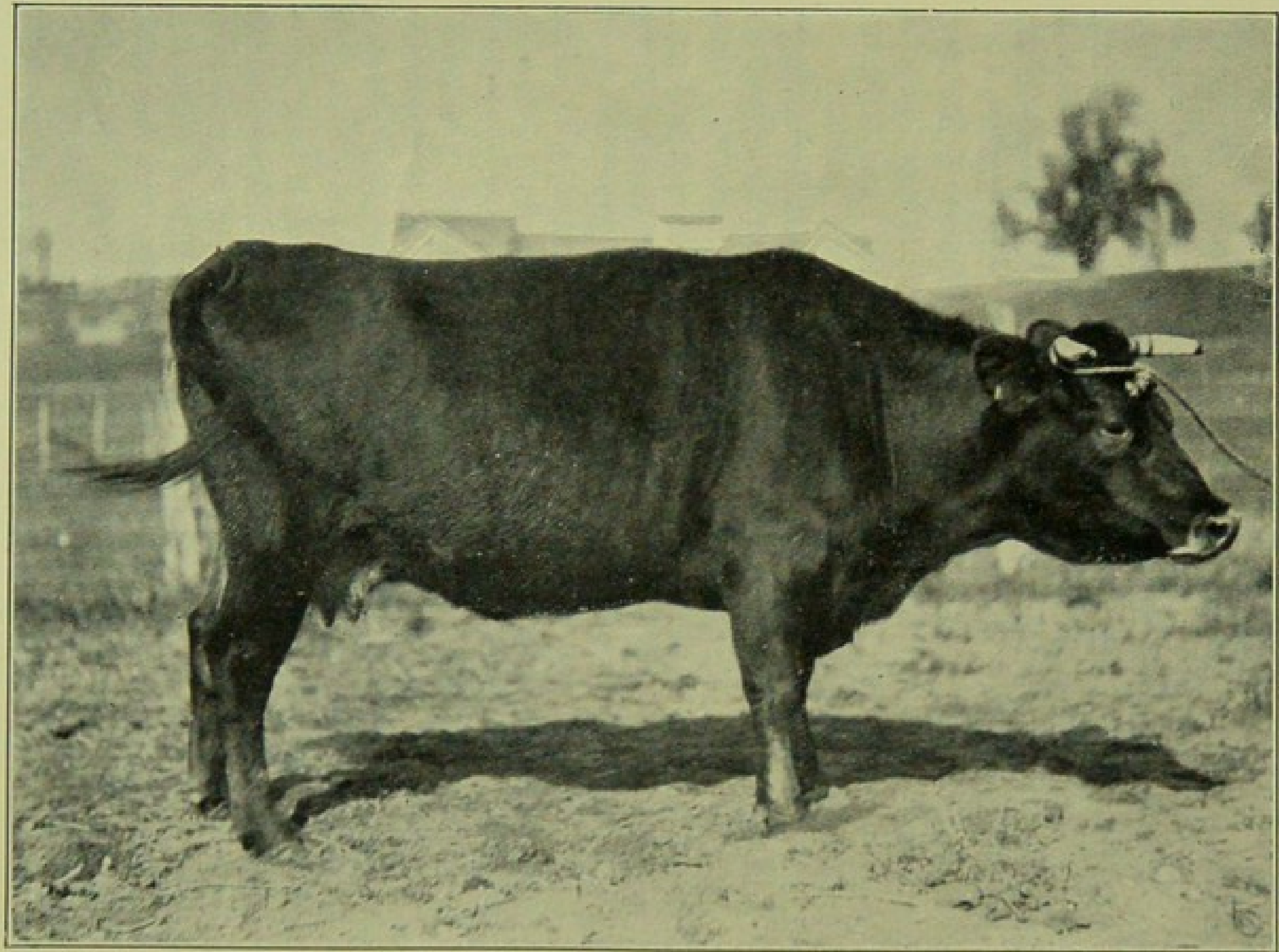
We have in this a strong argument for preventing the fæcal contamination of drinking water by the cows themselves.

In reference to the contamination of milk by fæces, Mohler and Washburn[4] state that "The number of cows shedding tubercle bacilli in this manner no doubt is far in excess of those producing tuberculous milk from tubercular udder lesions, and one of the greatest dangers of infection of man from tuberculous cattle may be found in this particular means of infecting milk through soiling it with fæces bearing tubercle bacilli." Dawson[5] confirms this view and Schroeder's contention in the following words: "....one cow in a herd may affect her calf by the bacillus-laden manure which soils her teats and adjacent parts; ....this manure may infect the milk,....her milk when added to the milk of perfectly healthy cows will infect the whole supply from that herd."

That market milk is almost invariably contaminated with fæcal bacteria is confirmed by Delépine,[6] and M'Fadyean agreed that "When 30 per cent. of the cows in a byre are tuberculous, the

1. 6th I. C. on T., Vol. 4, pt. 2, p. 609.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 628.
3. 3rd Interim Rept., 1909, p. 14.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 628.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 737.
6. 38th Annual Rept. L. G. B., Suppl., p. 349.

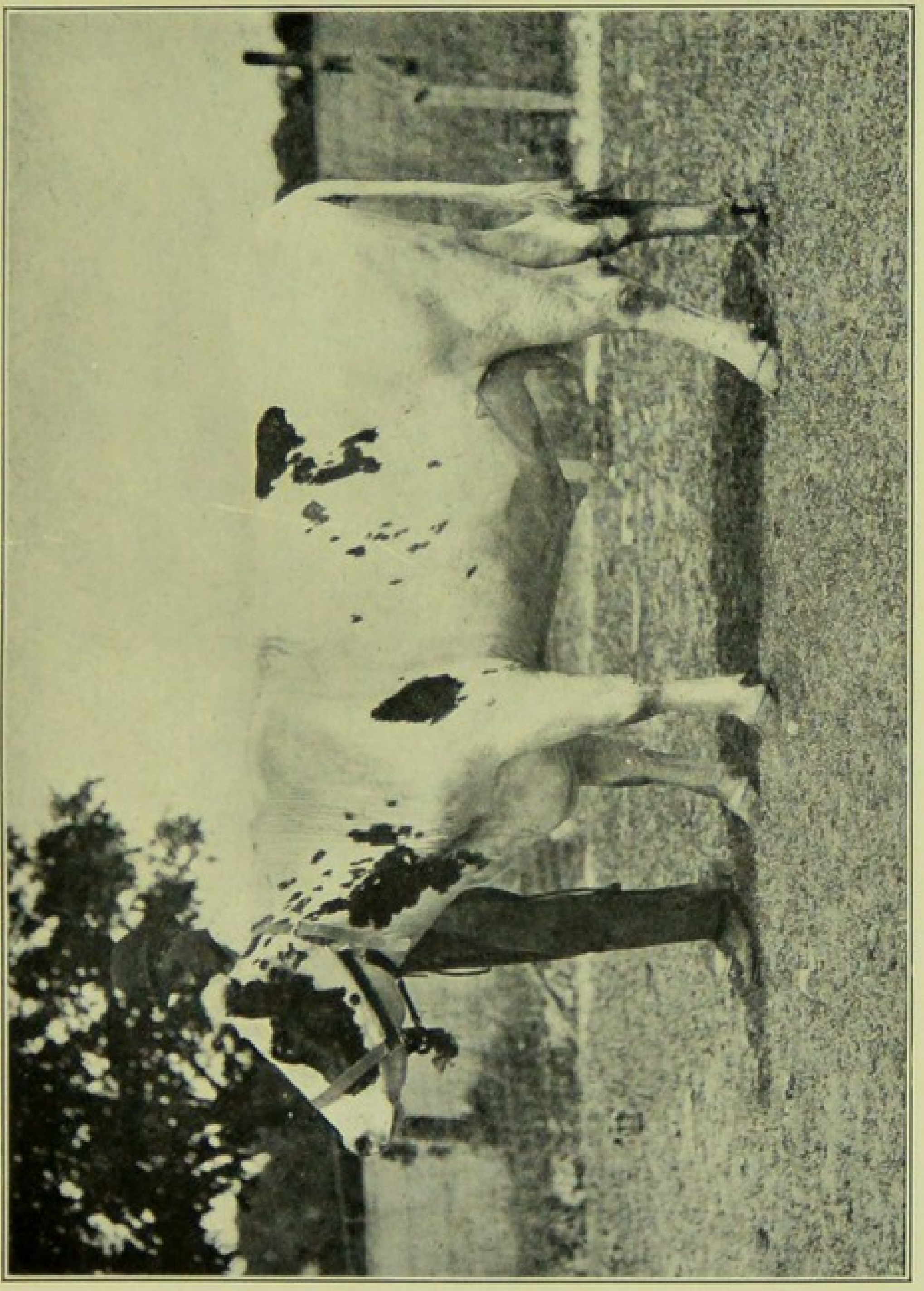
PLATE XIII.



A COW AFFECTED WITH ADVANCED TUBERCULOSIS.

The disease is partly located, as is shown by the position of her head, in the lymph glands of her throat. The glands are so much enlarged that, through pressure on the larynx, they greatly narrow the orifice through which air reaches the lung, and yet the visible bodily condition of the cow has remained very good, and is better than that of most dairy cows.

PLATE XIV.

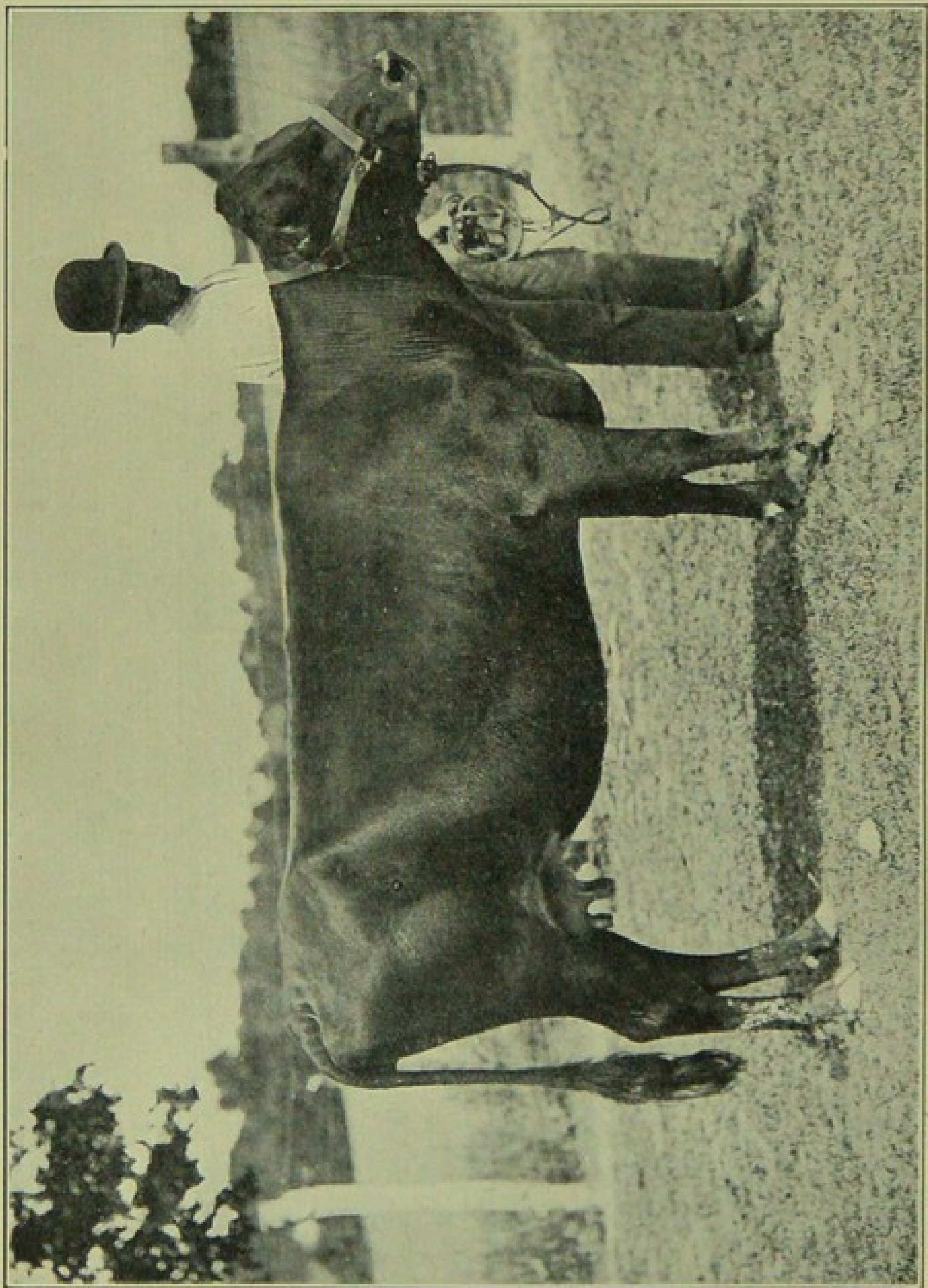


AN EXCEPTIONALLY DANGEROUS TUBERCULOUS COW.

At the time her picture was taken she was daily expelling a large number of tubercle bacilli per rectum with her fæces. Her general condition is good and she shows no symptoms of tuberculosis. Without the tuberculin test she would not have been known to be tuberculous and without other tests her uncommonly dangerous character would not have been suspected. It is not always possible to determine precisely how tubercle bacilli are expelled by individual tuberculous cattle; the tests for this purpose require too much time and careful observation for practical application.

PLATE XV.

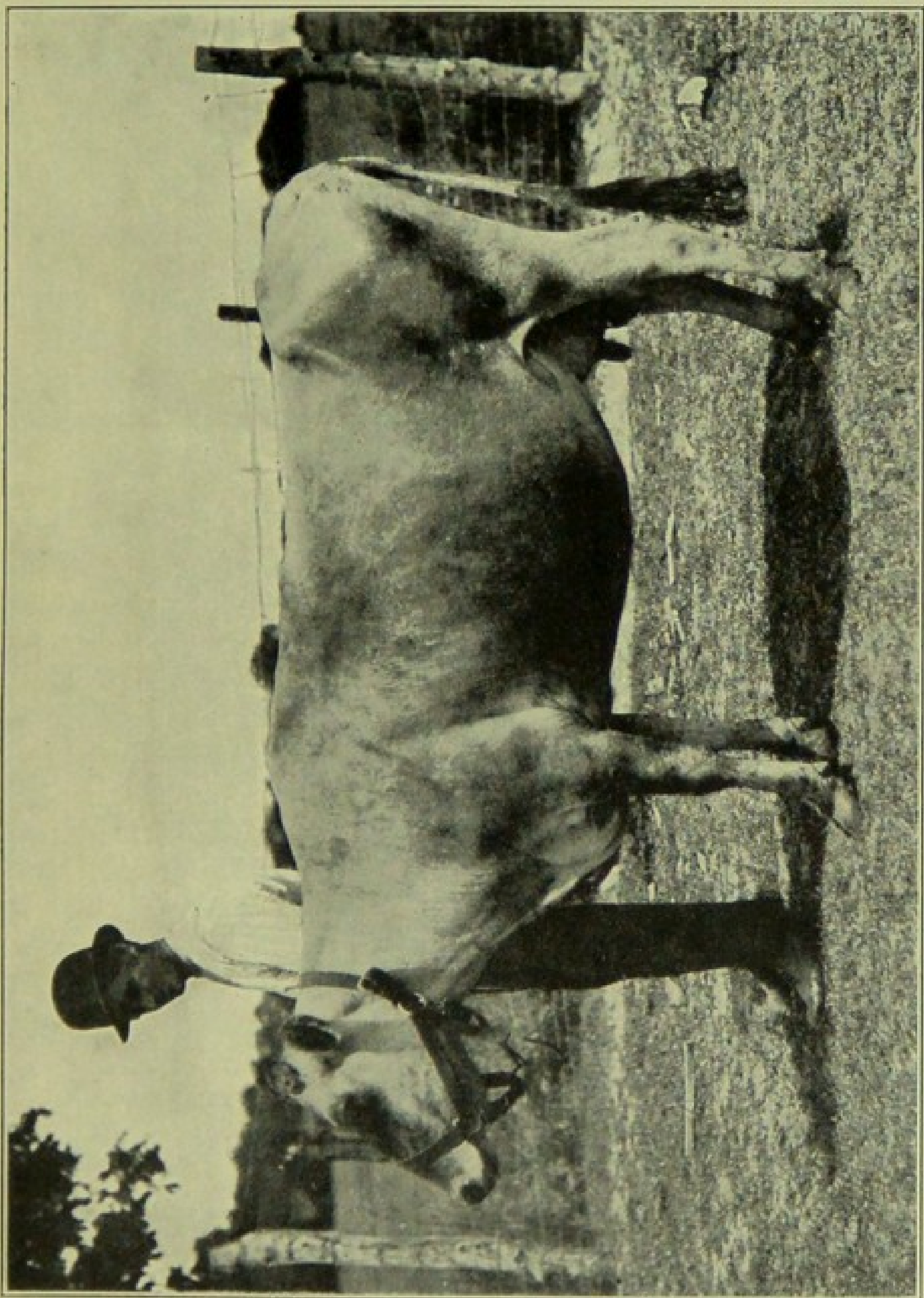
Bull. 56, Hygienic Laboratory.



A DANGEROUSLY TUBERCULOUS COW.

In appearance the subject of this picture is that of a well-kept family cow. She is dangerously tuberculous, because she expels tubercle bacilli from her body per rectum with her fæces.

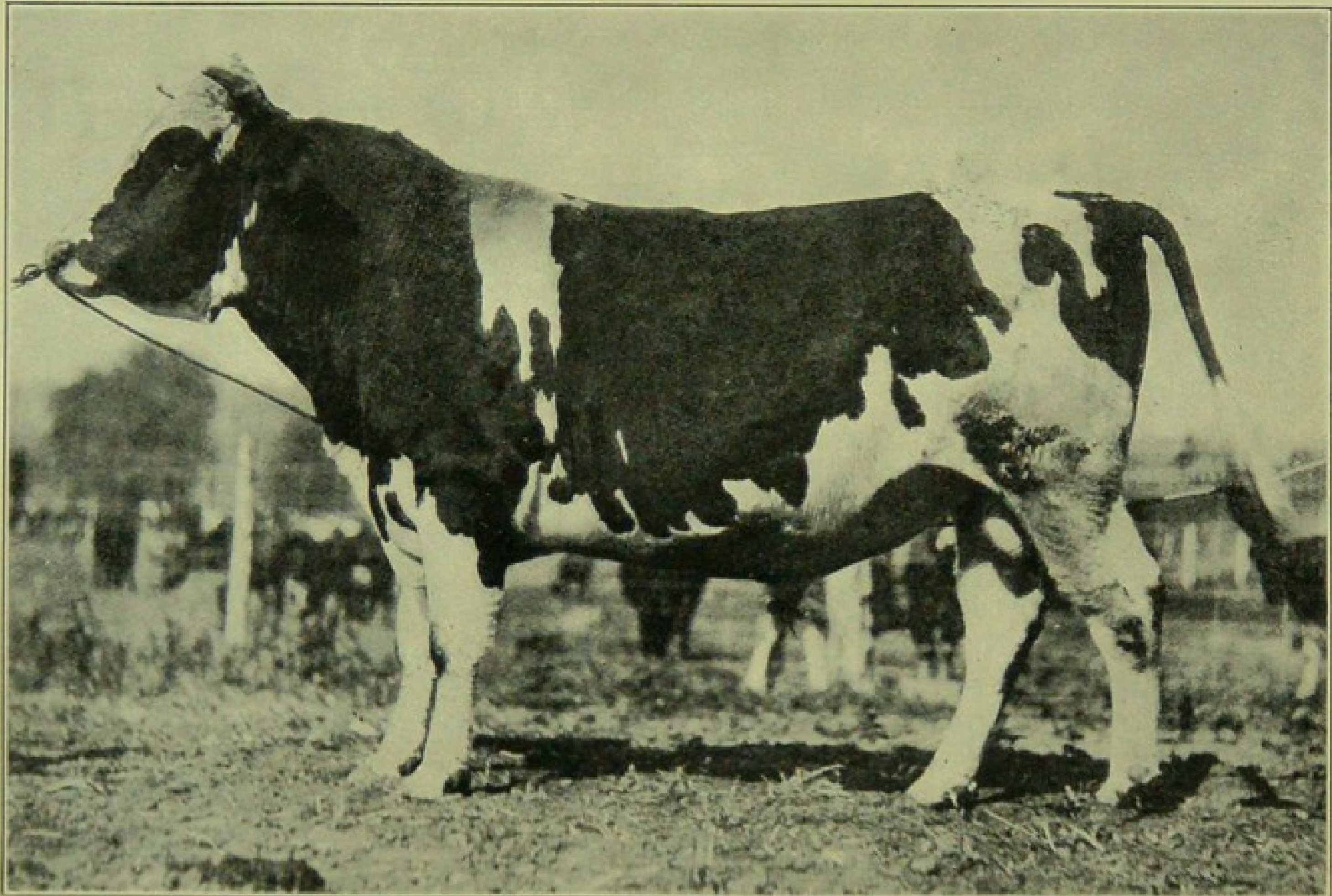
PLATE XVI.



A DANGEROUSLY TUBERCULOUS COW, KNOWN TO EXPEL TUBERCLE BACILLI PER RECTUM WITH HER FÆCES.

Tuberculosis is an infectious disease, and we must always bear in mind that it can be communicated from animal to animal and from animals to persons.

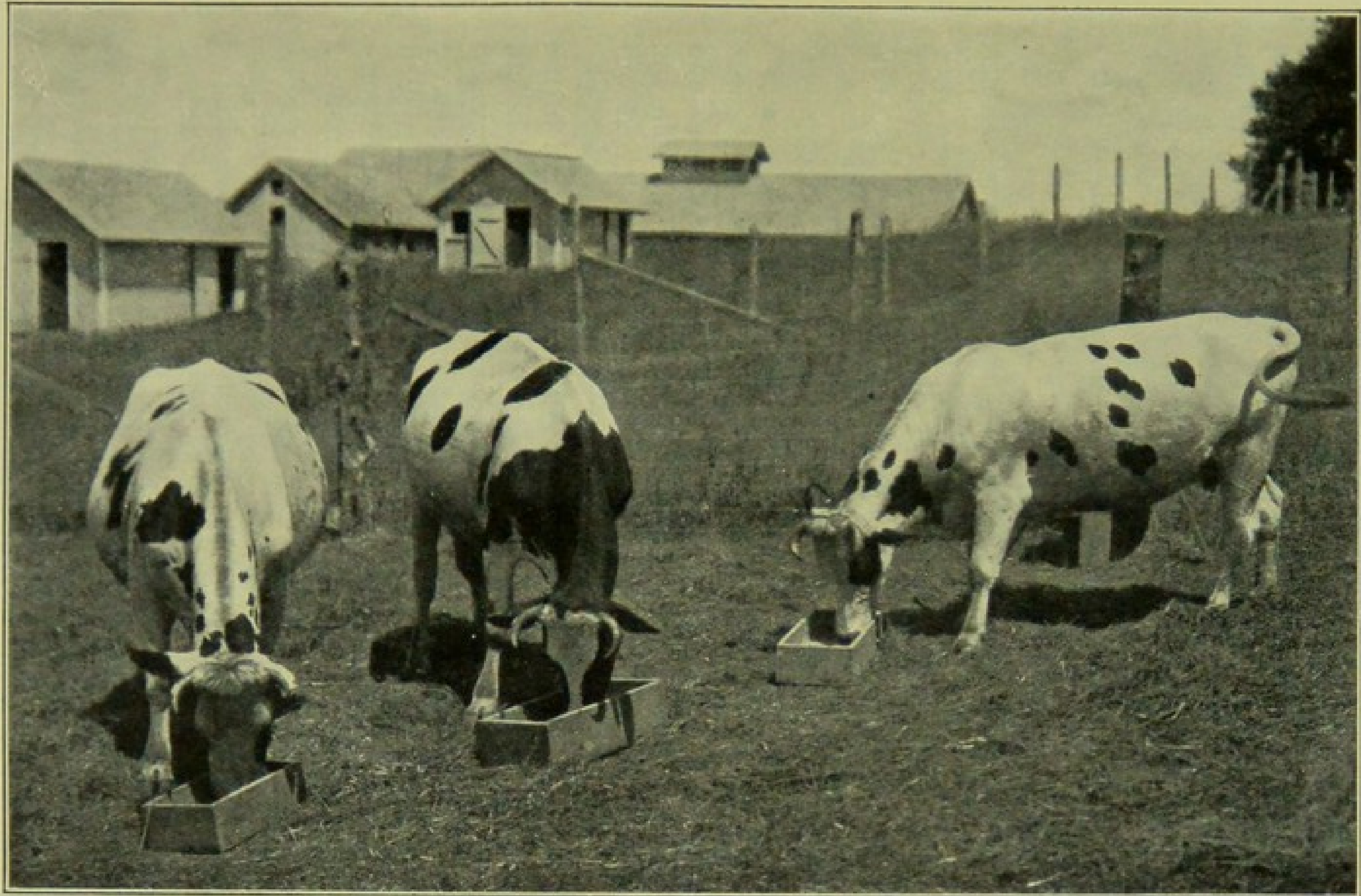
PLATE XVII.



A TUBERCULOUS BULL, KNOWN TO PASS TUBERCLE BACILLI PER RECTUM WITH HIS FÆCES.

When tubercle bacilli can be detected in the fæces they are probably numerous, because the opaque character of the material and the facts that the bacilli are isolated from each other and evenly distributed throughout the entire mass make it difficult to find them.

PLATE XVIII.



THREE TUBERCULOUS COWS.

The two on the right of the picture expel tubercle bacilli per rectum with their fæces, and probably also with the material slobbered from their mouths during eating. Tubercle bacilli that are passed from the bowels of cows usually have their origin in the lung and throat, from which regions they are coughed into the mouth and swallowed. The visible condition of the cows shows nothing of their dangerous tuberculous character.

dirt in that building, and the atmosphere in it, are almost certain to contain tubercle bacilli, and some of these are very likely to find their way into the milk. The more dirt milk contains, the greater is the chance that tubercle bacilli from that source may be present."

Tuberculous dust

Mohler[1] says that "It has been shown by Gaffky and Eber in Germany....that, even when the tubercle bacilli are not being excreted by the udder, the dust and manure of the stable where the diseased animals are kept are, in many cases, contaminated with tubercle bacilli."

Dawson[2] explains that "A single tuberculous cow that is passing the bacilli in her fæces will infect a whole stable sooner or later."

Jensen[3] states that tuberculosis of the intestines follows tuberculosis of the lungs and liver in mature cattle, and that it is recognised with difficulty by clinical examination.

A cow of average size passes about 30 lbs. per day of fæces, which [4]"....introduces an enormous amount of infectious material into their environment when they are affected with tuberculosis—much more than can be safely and economically disposed of so as to make this environment a proper place for the exposure of human food."

Schroeder[5] bases his conclusions on the following evidence under five heads.

First.—Cultures of tubercle bacilli of low virulence were mixed with a cow's drinking water. The cow's fæces were found virulent for guinea-pigs, thus proving "....that tubercle bacilli can pass through the entire length of a cow's intestinal tract and out with her fæces without losing their pathogenic virulence."

Second.—Numerous microscopic examinations made with the fæces of tuberculous cows and with the fæces of healthy cows, stabled, fed, and generally kept under precisely the same conditions, revealed that the fæces of the tuberculous cows contained bacilli like tubercle germs, and that the fæces of the healthy cows did not contain such bacilli. With the exception of a few cases the tubercle bacilli were not a constant factor in the fæces of the tuberculous cows; their occurrence varied from cases in which they were found with every examination to cases in which they were found with daily examinations only once every two to three weeks. This intermittent character of the expulsion of tubercle bacilli in the fæces is precisely what should be expected when we bear in mind that the bacilli have their origin in the lung, that tuberculosis in the lungs of cattle, because of the abundant interlobular connective tissue, is not accompanied by free cavity formation, and that cattle do not cough as freely or as violently as persons affected with lung tuberculosis.

1. P. H. and M. H. S., Bull. 56, p. 505.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 737.
3. Milk Hygiene, p. 72.
4. Schroeder, P. H. and M. H. S., Bull. 56, p. 534.
5. 25th Annual Rept. B. A. I., p. 118.

Third.—Guinea-pigs inoculated with small amounts of fresh fæces from tuberculous cows that were passing bacilli like tubercle germs per rectum became affected with typical, generalised fatal tuberculosis.

Fourth.—Cultures made from the bodies of guinea-pigs that succumbed to tuberculosis induced by the inoculation of fresh fæces from tuberculous cows were found to be pure cultures of tubercle bacilli, and such pure cultures were proved to be virulent for cattle. In one instance a cow inoculated subcutaneously with a culture of this kind became affected with rapidly progressive, generalised tuberculosis which terminated in death after a few months.

Fifth.—Hogs fed with the fæces of tuberculous cows contracted typical tuberculosis. The fæces were collected under conditions which ensure that no infectious material was introduced into them that did not pass from the bowels of the cows.

Schroeder[1] concludes that "It is well to assume that every tuberculous cow expels tubercle bacilli, because if she does not do so at one time, she will do so sooner or later in the course of the disease," and "....we are now in a position to say that the presence of cow fæces in milk, entirely apart from the impression it may make on the taste and appetite of the consumer, is *primâ facie* evidence that the milk, when it is obtained from a tuberculous dairy herd, contains pathogenic bacteria."[2]

In a special lecture delivered at the New National Museum, Washington, October 3rd, 1908, Professor Bang[3] seriously contemplated the danger arising from infection of milk with tuberculous fæces.

Delépine's view

Delépine,[4] though at first under the impression that milk might be fairly frequently dangerously infected by tuberculous discharges from the intestine or genito-urinary passages, and sometimes also by other tuberculous discharges, fresh or dry, concluded, as a result of his very exhaustive and extensive work, that "These sources of infection do not, however, appear to play a very important part."

In short, when Delépine found tuberculous milk, the Public Health officials of Manchester traced it to its source, and having found and eliminated the tuberculous udders, the infection, in the great majority of cases, ceased. Delépine is, therefore, satisfied that the most important and dangerous source of tuberculous milk is, in the great majority of cases, the tuberculous udder.

The professor says [5]"The dung may contain a large number of tubercle bacilli. It must, however, be admitted that when the cow is properly groomed and handled, and when the milkman is clean and takes a moderate amount of care, the amount of excreta entering the milk pail accidentally must be extremely small. Even when

1. 25th Annual Rept. B. A. I., p. 122.
2. B. A. I., Circular 118, p. 6.
3. 6th I. C. on T., Special Vol., p. 215.
4. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 254.
5. 38th Annual Rept. L. G. B., Suppl., p. 354.

the cow, milkman, and stable are dirty, the comparatively small amount of infectious matter introduced in this way is diluted with the milk of several cows, and ultimately the number of tubercle bacilli derived from the dung is exceedingly small when compared with the number derived from the udder."

Dr. Stevens,[1] Medical Officer of Health, County of Renfrew, in his "Report on Dairies, Cowsheds, etc.," dated August 9th, 1909, deplores the nuisance he has observed in his district of cows leaving droppings on the sidewalks as they are being driven to and from the byre at night. He points out that this practice is an offence punishable by fine in some American towns. "The material," he continues, "is sometimes spread out with a brush, but never washed off till the rain comes. Tubercular bacilli in millions have been found in such material from diseased cows. How about the other cows grazing in the same field, and the rabbits, which are so susceptible to tubercular disease? And how about the children who spend so much of their time on the pavements, and are not so fastidious as to what they pick up and put into their mouths?"[2] (See "Schmutz" Infection, hereunder.)

Mr. David Allen, V.S.,[3] states that rabbits act as carriers of tuberculosis. Mr. Cameron[4] confirms this view.

It is reassuring, however, to find that, as Nocard[5] informs us, "The rabbit and the guinea-pig are very rarely tuberculous under natural conditions....," while Dr. Isidore Spitzstein says that the rabbit is decidedly refractory to the disease (see p. 151).

"Schmutz" Infection.

Many writers have attached great importance to this mode of infection—"Schmutz" infection—of the Germans. Ostermann[6] inquired critically into the mechanism of the "Schmutz" infection in the houses of 20 infected families where the conditions were exceptionally bad, even for Breslau, a very dirty town. "Of 42 children examined, bacilli were found (by injection of washings into guinea-pigs) in four only. Examination of the floors gave results in 50 per cent." He thinks this proportion very small when the extreme filthiness of the houses is taken into consideration, and, in connection with other researches by fellow-workers, thinks that they indicate the rarity of "Schmutz" infection. Investigating adults, he examined the hands of 14 consumptives, finding the bacilli on seven; also on the hands of one healthy nurse. Are these transferred in hand-

1. Dr. Stevens' Rept., p. 20.
2. One might also inquire regarding flies and birds that feed on the dung.
3. See The Scottish Farmer, Nov. 19th, 1910, p. 1035.
4. See The Scottish Farmer, Nov. 19th, 1910, p. 1035.
5. The Animal Tuberculoses, Introduction, p. viii.
6. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.

shaking, etc. ? The spores of a harmless saprophyte (microbe unconnected with disease) were rubbed on the hands of one person and allowed to dry. His own thumb was then rubbed on the infected palm, the organisms washed off the thumb and plated. At the most, only one out of the 700 spores were transferred. A rich tuberculous sputum was then dried on one hand and a second hand vigorously rubbed on the infected hand. The washings of the second hand were injected into guinea-pigs with negative results in every case. Is the nose or mouth likely to be infected from the infected second finger ? A finger pad was infected with a known number of spores, then immersed with a slight rubbing movement in broth,[1] which was subsequently plated. The time of immersion was found to be a most important factor. For one second 1 to 500, 1 to 343, 1 to 9, and 1 to 8 were the maxima in a series of experiments. Ostermann sums up the possibilities of contact infection in adults as follows: There may be a thick layer of dry sputum on a consumptive's hand; a healthy person by a long and heavy grasp might transfer some to his own hand; he might then suck it off his fingers into his mouth—all remotely possible, but highly improbable.

INFECTION OF HOGS BY TUBERCULOUS DUNG.

If any doubt remain regarding Schroeder's contention of the liability of human infection arising from tubercle bacilli in bovine fæces, there seems no doubt of this source of infection for hogs.

Dr. Peters[2] (Nebraska) joined the discussion on Schroeder's paper in stating he had "....found that in the West tuberculosis in hogs is more frequently contracted from the infection of the fæcal matter than through milk. I am unable to state," he continued, "whether it was open tuberculosis or not, but I can give the record of 122 farms visited. These farms were visited for the purpose of learning why tuberculosis existed in our State. The dairymen were resenting the claim that it was caused through milk, and so we found by visiting these premises that more than half of the farmers never fed milk to the hogs at all. A large proportion of the hogs follow the cattle.....I believe there is a great deal of danger from that source; at least, we have found it so after careful examination."

Dr. Burton Rogers, of Manhattan, Kansas, has studied this problem closely. We shall not go to any length in the matter, as the following of hogs is not popular in the United Kingdom.

"Agricultural economy in animal husbandry," says Rogers,[3] "has proved that it is profitable to have omnivorous hogs secure a part of their ration from the partially nutritious droppings of cattle, **Following of hogs**

1. "Broth" is the term used by bacteriologists for a beef tea concoction containing peptone, and used as food for bacteria.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 611.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 841.

especially if the cattle are overfed and undigested food passes through with the fæces. Therefore, hogs are encouraged to, and do, satisfy their voracious appetites by snooting and rooting in and devouring the droppings of fæces of cattle, and as a result become tuberculous proportionate to the degree of their individual resistance and the numbers of virulent tubercle bacilli in the fæces."

During the winter of 1907-8 [1]"....the Experiment Station at Ames, Iowa, knowingly and purposely forced 28 healthy pigs to follow non-reacting, tuberculin-tested, and therefore healthy, cattle in the same feed lot or pens ; and likewise forced 20 other healthy pigs to follow cattle that had reacted positively to the tuberculin test, and were, therefore, tuberculous. A few months later the hogs were slaughtered and inspected, and none of those following the healthy cattle were tuberculous, while 21 out of the 28 following the tuberculous cattle were tuberculous. Not only did the tuberculin, but so did the hogs, test the cattle."

Hogs detect bovine tuberculosis

" In the summer of 1904, while a Federal veterinary inspector in an Iowa town,...." Rogers[2] " tagged 3,430 of the hogs that were brought to the packing house in individual wagons by the individual farmers within a radius of 20 miles. These hogs were slaughtered separately from car-load lots of shipped-in hogs, and during the experiment only 39 of the 626 different farmers in an exceptionally bad tuberculous district brought in all the tuberculous hogs."

In this way Rogers shows how the ear tagging of hogs at the farms would enable the authorities in his country to locate tuberculosis in cattle.

All these hogs [3]"....test the degree of dangerousness of the environment to which they were exposed, and of the food which they ate. The environment and similar food is still left for other hogs and man and babies. No more accurate and final feeding test could be purposely arranged for and conducted by scientists than this one going on naturally—yet no advantage is being taken of it."

Considering that two thorough *post-mortem* examinations are made on the carcasses of hogs, under official inspection, Rogers' proposal seems sound and practical.

Hog-association test for tuberculosis in cattle

Rogers further proposes to confirm the tuberculin reaction in valuable cattle by feeding the fæces to hogs. By such a hog-association test there might be saved to the wealth of the country (U.S.A.) a large number of animals which are at present destroyed.

Newsholme[4] points out that " Tuberculosis is very prevalent in pigs only when a large dairy industry is carried on. The slaughter-house reports of Copenhagen for 1897 show that the proportion of tuberculous pigs varied from 3 to 14 per cent. ; while in Bavaria, in

1. 6th I. C. on T., Vol. 4, pt. 2, p. 842.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 841.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 841.
4. The Prevention of Tuberculosis, p. 145.

which there is only a small dairy industry, only 0·2 to 0·4 per cent. of the pigs slaughtered in 1896-1900 were tuberculous."

Confirming the recommendations of Rogers, the International Commission on the Control of Bovine Tuberculosis[1] state that experimental work of this character has given very interesting results. "For instance, when the occurrence of tuberculosis amongst hogs at an abattoir is followed up by a tuberculin test of the cattle on the home farm, it practically always discloses tuberculosis among these animals.

"Like much other evidence, this encourages us to believe that tuberculosis among hogs will cease to exist as an economically important problem as soon as we succeed in controlling the bovine source of tubercle bacilli."

Tuberculous separated milk and separator slime as sources of swine tuberculosis will be referred to on p. 344.

Infection from slaughter-houses

In passing, we may mention another source of hog infection discussed by Noack.[2] "The slaughter-houses," he says, "especially where no control by local authorities has been exercised have been centres of infection and distribution of diseases, especially tuberculosis, because it will happen to every butcher that, in the course of time, he may kill an animal more or less so afflicted. In many instances the tubercular material has been fed to hogs, and, as experience has proved, they contracted the disease.

"How bad the conditions in such slaughter-houses are may be easily recognised from a few cases, which I shall refer to, and which were revealed by the State Meat Inspection Service of Pennsylvania.

"On the premises of a slaughter-house, in the north-western part of the State, 48 hogs were kept, of which 37 were so badly afflicted with tuberculosis that most of them were found to be unfit for human food. In another slaughter-house, in the central part of the State, six hogs were quarantined, of which two were killed showing tuberculosis, while the other four died of the disease during the following three months."

MEAT AS A CONVEYER OF TUBERCULOUS INFECTION.

"The flesh from tuberculous cattle," says Newsholme,[3] "is undoubtedly sometimes infective. Much evidence on this point was collected by the English Royal Commission of 1895. It was shown that uncooked tuberculous material given as food to guinea-pigs, calves, pigs, and cats produced tuberculosis. In 'joints' of meat it is exceptional to find tuberculous nodules or other evidence of disease, though to a practised eye the 'stripping' of the pleura lining the ribs gives rise to suspicion of tuberculous 'grapes' removed in

1. Rept. Int. Com. on C. of B. T., p. 21.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 988.
3. The Prevention of Tuberculosis, p. 140.

the dressing of the animal. S. Martin, in his experiments for the above Commission, frequently produced tuberculosis by inoculating or feeding animals with flesh from tuberculous cattle, ' in which no tubercle could be detected by his ocular tests.' This led him to consider the ' real and considerable danger ' of the meat becoming contaminated by the butcher's hands, knives, and cloths, which had been previously in contact with tuberculous lesions in the animal. ' The greater the amount of tubercle there is in the cow,' the more likely ' is the sticky caseous matter to get smeared over the carcass.' Thus he failed to produce tuberculous disease by feeding animals on meat from cows with mild or moderate tuberculosis, though inoculation of test animals might be successful ; while feeding with meat from cows with advanced or generalised tuberculosis succeeded in producing tuberculosis.

"The main tuberculous lesions in cattle are found in the organs, membranes, and glands ; but seldom in the flesh or meat substance. Naked-eye evidence of disease has, therefore, usually been removed from the dressed carcass, with the possible exception of a few pea-like tubercles internal to the ribs or about the diaphragm, or a few small glands in certain ' joints.'. . . .

"The fact that during a period in which the consumption of meat has greatly increased, human tuberculosis has greatly declined, does not favour the view that tuberculous meat has played a large part in its causation. I am not aware of any evidence that the proportion of tuberculous cattle is markedly less than formerly."

Risk with raw meat

[1]"The cooking of meat affords a considerable measure of protection, as all, except underdone parts, would be sufficiently sterilised. With uncooked meat, which is often given in the form of pounded meat or juice to weakly children, there must be considerable risk; and doctors prescribing such meat should give preference to meat derived from animals known to have been slaughtered at a public abattoir.

"The Second Royal Commission on Tuberculosis (1898) laid down the following principles in the inspection of the tuberculous carcasses of cattle :—

"'(*a*) When there is miliary tuberculosis of both lungs,
(*b*) When tuberculous lesions are present on the pleura and peritoneum,
(*c*) When tuberculous lesions are present in the muscular system or in the lymphatic glands embedded in or between the muscles,
(*d*) When tuberculous lesions exist in any part of an emaciated carcass

} The entire carcass and all the organs may be seized.

1. The Prevention of Tuberculosis, p. 404

<table>
<tr><td>(a) When the lesions are confined to the lungs and the thoracic lymphatic glands,
(b) When the lesions are confined to the liver,
(c) When the lesions are confined to the pharyngeal lymphatic glands,
(d) When the lesions are confined to any combination of the foregoing, but are collectively small in extent</td><td>The carcass, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized.'</td></tr>
</table>

Pork

"They add that 'In view of the greater tendency to generalisation of tuberculosis in the pig, we consider that the presence of tubercular deposit, in any degree, should involve seizure of the whole carcass and of the organs. In respect of foreign dead meat, seizure shall ensue in every case where the pleura have been stripped.'

Foreign dead meat

"These rules, where adopted, give a fairly good guarantee against the entry of tuberculous meat into the market. They are fairly well enforced in all public abattoirs, and possibly in a majority of private slaughter-houses in towns ; but in rural districts there is no efficient control. It is not even obligatory that animals should be slaughtered in a registered or licensed slaughter-house, and when an animal is killed on the farm, there is no enactment compelling the submission of the carcass to inspection by a competent inspector. Such inspectors often do not exist in rural districts. A large amount of diseased meat is prepared for the market on unlicensed premises in country districts, and is smuggled into towns. The one essential for improvement is that no meat should be allowed to be exposed for sale, or to be conveyed from place to place (except when it is consigned to a clearing house or public abattoir for inspection), unless it is stamped in some way, to vouch that it has been properly inspected.

"The following extracts from the above report (1898) emphasise, as strongly as is needful, the evils of the present state of things :—

"'So long as private slaughter-houses are permitted to exist, so long butchers, from use and wont, will continue to use them, and so long must inspection be carried on under conditions incompatible with efficiency ; besides other disadvantages and risks to health which lie beyond the scope of our reference.'"

The recommendations of the Royal Commission were in the direction of the establishment of public slaughter-houses under qualified inspection, a theme which many able writers have since dilated upon.[1]

The discussion of infection from meat does not appear to have progressed far beyond pointing it out as a possible danger.

1. See E. Petronell Manby, M.D., D.P.H., Thompson Yates' Reports, Vol. 2, p. 45.

It is contemplated in this light by Salmon,[1] Jobson,[2] Wladimiroff,[3] Bang,[4] and Mohler.[5] The two latter authorities state, however, that as a source of tuberculous infection meat is of less importance than milk. Green and Kotz[6] inquire, " Must not more stringent laws be enacted and enforced with regard to the use of infected meat ? "

Turner's views

Dr. Pickett Turner[7] insists that the importance of infected meat is not generally realised. Why, then, is tuberculosis so rife among the Japanese, who do not eat meat nor drink much cow's milk ? He does not believe it is tuberculosis—as we know it in the Western world—neither does he believe that the tuberculosis of birds and fowls is identical with the human disease, but thinks it may be really actinomycosis, a disease due to a parasite—the ray fungus—capable of finding its way to the human lung and setting up phthisis indistinguishable clinically from that produced by the tubercle bacillus[8] (see Appendix A). Why is there so little of the disease among Jews ? Because they are more particular in the selection of their meat. They are not content to cut out the diseased parts and eat the rest.[9] The slightest sign of disease is sufficient to condemn the whole carcass for the Jews ; but the Gentile may buy it from the *kosher*.[10] Moreover, tuberculosis *is* rife among the very poor Jews who cannot afford *kosher* meat.

The supervision of slaughter is a religious function among the Jews. Among the Gentiles it is supervised by any handy men who pass a little examination in hygiene.[11]

Turner points out that veterinarians often fail to detect disease by clinical signs in the living animal, and that it would sometimes require considerable labour in the hands of a skilled pathologist to determine the wholesomeness of meat.

He thinks we live in a sense of false security regarding the destruction of micro-organisms in meat by cooking, and refers to the statement of the distinguished bacteriologist Dr. Sims Woodhead to the effect that bacteria in the interior parts of joints are not killed by cooking.

Moreover, we know that trichinosis is conveyed to man from the trichinæ surviving in " underdone " pork.

1. B. A. I., Bull. 38, p. 78.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 765.
3. 6th I. C. on T., Special Vol., p. 139.
4. 6th I. C. on T., Special Vol., p. 214.
5. P. H. and M. H. S., Bull. 56, p. 504.
6. 6th I. C. on T., Vol. 2, p. 397.
7. Tuberculosis : Its origin and extinction, pp. 18, 54. London, 1906.
8. Tuberculosis : Its origin and extinction, p. 33.
9. Tuberculosis : Its origin and extinction, p. 50.
10. Tuberculosis : Its origin and extinction, p. 52, quoting van Thol.
11. A. M. Trotter, M.R.C.V.S., Chief Veterinary Inspector for the City of Glasgow, mentions the superannuated policemen in this connection (see The Scottish Farmer, Jan. 28th, 1911, p. 79). Barnes states that "Nearly every trade and profession is represented" among the meat inspectors (see Report of 26th Ann. Congress, The Roy. San. Ins., Belfast, 1911, p. 280).

Regarding the standard of knowledge required for meat inspectors, Leighton and Douglas[1] are distinctly in accord with Turner. They are of opinion "....that the meat inspector of the future should be one who has passed through a thorough training in theoretical and practical pathology and bacteriology, such as is given in the various veterinary colleges."

It is very doubtful whether the figures for tuberculosis among Jews who are able to afford *kosher* meat are comparable with those for the general population. The careful selection of meat is not by any means the only protective influence in the social and domestic life of the particular Jews who are a careful and abstemious class. We have sought to apply a similar mode of reasoning to account for the prevalence of phthisis among the Indians who eat raw meat[2]; but a superficial examination of the conditions shows at once that the argument is complicated by the degeneracy of the tribes, so that it breaks down entirely.

Fishberg disagrees

Fishberg[3] is distinctly in opposition to Turner. He says "In Eastern Europe, where the Jews follow the dietary laws, strictly adhering both to the letter and spirit of the sacred ordinance, there is more consumption among them than among their co-religionists in Western countries, who disregard the dietary laws in part or completely. In Germany, France, England, Italy, etc., where the majority of the native Jews are constantly seen eating in Christian restaurants, and many are not particular to procure *kosher* meat at home, there is less consumption among them in Eastern Europe, the East End of London, or the East Side of New York City, where they, poor as they generally are, pay exorbitant prices for meat which is, or is alleged to be, *kosher*."

Considering that so few have attained to the Jewish admirable ideal it must be conceded that the determination of the wholesomeness of meat may be a matter of considerable labour to a skilled pathologist; but whether it is justifiable to condemn a whole carcass because of a single small lesion may be viewed from an economic standpoint as well as that of a religious rite.

The question is whether the dangerous meat can be detected by inspection.

Detection of infected meat

On this point "The experiments of Kastener, Hoefnagle, and Westenhoeffer are especially of interest," says Mohler,[4] "as well as of great importance, because they took into consideration the extent, character, and condition of the tuberculous lesions. In one series of tests Kastener fed to experiment animals meat from cattle which were affected with localised tuberculosis, the carcasses of which had been passed for food. In this series he could not obtain a single positive result, while with meat of condemned tuberculous carcasses his results

1. The Meat Industry and Meat Inspection, Vol. 3, p. 817.
2. See Ohio Agricultural Experimental Station Bull. 108, p. 341.
3. 6th I. C. on T., Vol. 3, p. 422.
4. 25th Annual Rept. B. A. I., p. 159.

in every instance were positive. It is, therefore, apparent that the condemnation of tuberculous meat is carried out not only from an æsthetic standpoint, but because there is sufficient proof at hand which points to the danger that might arise from the ingestion of such meats. For this reason it appears desirable to have all products coming from animals affected with tuberculosis, as well as the slaughter and disposal of such animals, placed under the supervision of an experienced inspector. Since the flesh of all tuberculous animals is not equally dangerous, there must be rational discrimination between the meat of slightly or locally diseased carcasses and that of the more extensively diseased carcasses, the former having experimentally given negative results, the latter proving to be infectious."

Wm. H. Park, M.D.,[1] of New York, says "The occasional occurrence....of tubercle bacilli in the flesh of sheep and hogs is of little danger, since such food is cooked before eating and is given rarely to the very young, who are the most liable to infection."

Dr. H. H. Clarke,[2] of Liverpool, confirms this view.

Among their summary of results of investigations relative to the danger to human health from animal tuberculosis, the German Imperial Health Office[3] state that " A conscientiously conducted meat inspection constitutes an important protection against the transmission of the tubercle bacilli to human beings through meat ; there is also protection afforded by the proper preparation of meat (thorough boiling or roasting)."

Kellogg[4] states that "The temperature of the interior of a portion of meat seldom reaches the boiling point during cooking." The tubercle bacillus succumbs at a temperature considerably below the boiling point, however, as we have seen in connection with Pasteurisation (Section III.).

Russell and Hastings[5] state that " There is little danger from meat, as tuberculosis does not usually affect the muscles, and besides, the heating to which meat is subjected in cooking is sufficient to destroy the tubercle bacillus."

In connection with tuberculosis in meat, it is interesting to note that [6]" Sheep and goats are rarely affected, probably because of a natural tendency toward immunity, or because they are not generally exposed to infection."

These animals, as pointed out by the late Professor Owen Williams,[7] may resist subcutaneous inoculation with tubercle bacilli, but they are not proof against its intravenous inoculation.

1. 6th I. C. on T., Vol. 1, pt. 1, p. 157.
2. Studies in Tuberculosis, p. 25.
3. Zeit. f. Tuberkulose u. Heilstättenwesen, Bd. 7, H. 6, pp. 546-7. Leipzig, October, 1905. Quoted by Salmon, B. A. I., Bull. No. 38, p. 78.
4. 6th I. C. on T., Vol. 3, p. 762.
5. Wis. Agri. Exp. Sta. Cir. of Information, No. 23, p. 10.
6. Melvin, 25th Annual Rept. B. A. I., p. 98.
7. Veterinary Medicine, p. 348.

Hughes[1] confirms the freedom of sheep from tuberculosis. When the disease is present it appears to be the result of infection, according to Salmon,[2] from bovine sources.

Hughes[3] states that "Whether there is danger of transmission of bovine tuberculosis to man or not, the American people are unalterably against the use of badly infected carcasses for food, or the milk of tubercular animals for food."

The frequency of the tapeworm in human beings is proof, says Turner, [4]"....that the story of its being killed in cooking is nonsense," and it is argued that if these entozoa can survive, it is evident that the *Bacillus Tuberculosis* can also withstand cooking, seeing that it is known it can withstand a temperature ten degrees higher than the entozoa (Turner, p. 54).

Leuckart,[5] however, maintains that the occurrence of tapeworms in humans "....is by no means exclusively determined by the consumption of flesh, but quite as much, and indeed almost more, by the condition and preparation of the meat. And the more frequently the latter is eaten in a raw or half-raw condition, in consequence of local or individual custom, the more does the danger of infection increase."

Krabb's 53 cases are referred to, and among these a relatively large number of Germans occurred. This is explained to be due to the fact that the latter, even in foreign countries, adhere to their custom of eating raw flesh and fresh sausage, and of usually procuring the latter in small quantities from the butcher's shop. The same is asserted of the Germans in Paris, among whom the tapeworm, according to Lancereaux,[6] also seems to occur with unusual frequency.

The possibility of infection with the bladder worm of pork (which worm develops into the tapeworm in the human being) is always present, says Leuckart, wherever raw pork is stored, and the transmission may be effected by the most manifold objects. Under some circumstances, even the hand is quite sufficient, especially since, to quote the common saying, there is but a short road from it to the mouth.

Some stress is laid upon the frequency of the infection among cooks and housemaids, who have special opportunities of eating partially cooked pork.

RESOLUTIONS OF THE NINTH VETERINARY INTERNATIONAL CONGRESS, AT THE HAGUE, SEPTEMBER, 1909, CONCERNING MEAT INSPECTION.[7]

"(1) With reference to the conclusions, proposed by the Obermedizinalrat Professor Dr. Edelmann, Dresden, in correspondence

1. 6th I. C. on T., Vol. 4, pt. 2, p. 959.
2. B. A. I., Bull. No. 38, p. 8.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 980.
4. Tuberculosis: Its origin and extinction, p. 17.
5. The Parasites of Man, p. 531. Edinburgh, 1886.
6. Arch. gener. Med., t. xx, p. 553.
7. Resolutions of the Ninth Inter. Vet. Congress at The Hague, Sept. 13th-19th, pp. 45 *et seq.*

with the conclusions proposed by the other reporters, and passed in the sense of the discussions, the Congress insists once more on the high signification of obligatory meat inspection for public health and sanitary police.

"(2) The Permanent Committee of the International Veterinary Congresses is requested to inform the governments of such States as have not yet introduced obligatory inspection of meat of the resolutions of the Congress.

"CONCLUSIONS OF MR. EDELMANN AND OF THE OTHER REPORTERS.

"(1) The principal object of the obligatory inspection of meat, instituted by the State, is to protect human health from the dangers threatening by the use of meat.

"(2) This inspection must extend in the first place to the animals usually killed for consumption in the country, except rabbits and fowls.

"Whether fresh or prepared, the meat imported into a country must also be inspected.

"(3) Only veterinary surgeons are designated by their technical knowledge to have charge of the inspection of meat and of the control of meat products.

"Inspection by other persons than veterinary surgeons (laymen, empirics) ought not to be allowed, or only by reducing their use as much as possible, and whenever the services of a veterinary surgeon would involve complications or expenses beyond the object in view.

"(4) It is in the interest of the inspection to be what it should and could be, to give the technical inspectors a proper social position, with corresponding remuneration.

"(5) The practice of obligatory inspection of meat in the name of the State means examination of the animals before and after slaughtering (inspection of the animals and of the meat).

"The exemption for animals killed for private use is not without presenting some dangers from the hygienic point of view. If, however, this exemption is accorded, it must never be for animals killed on account of their being sick.

"(6) Inspection ought not to be abandoned in relation with trichinosis, where their presence in pigs, boars, and dogs, and the fact that all the trichinæ contained in the meat are not rendered harmless with certainty by the preparation that this meat undergoes in order to serve for human consumption, is to be taken into consideration.

"(7) For the inspection to be complete and deserving as much confidence as possible, resorting to any method that has proved to be good cannot be neglected; especially for the discovery of hurtful micro-organisms, bacteriological examination is indispensable.

"(8) In establishing the principles upon which inspection of meat shall be regulated, it is necessary to take always into consideration the positive results obtained by scientific researches, and, in case there is no objection, with regard to sanitary reasons, to apply them as liberally as possible.

"(9) The division of meat into good, conditionally good, inferior, and bad meat is practically to be applied.

"Whether it is necessary to make the distinction of inferior meat depends upon what is required by the consumers.

"(10) Bad meat must be disposed of in such a manner that in no way the germs of disease can be propagated.

"(11) The utilisation of conditionally good meat and, if necessary, of inferior meat, ought to take place only in the town of slaughtering, or in a region as small as possible and under police control.

"(12) Obligatory inspection of meat in a State ought to be placed under a central direction. Experience has demonstrated the necessity of an efficient control of the inspectors, especially of those who are not veterinary surgeons.

"(13) A regular statistic, made up by the inspectors by daily annotations, is economically and scientifically of great value.

"(14) It is recommendable to extend the examination to other animal food, especially game, fowls, fish, crustaceous animals, and molluscs.

"(15) It will be good to complete the official obligatory inspection of meat by a control, made by veterinary surgeons and police officers, of the trade in meat in markets as well as in slaughter-houses and manufactories of meat products.

"(16) One cannot insist too much on the great importance of official abattoirs with regard to general hygiene and the examination of meat. In larger towns municipal abattoirs are to be erected. For smaller towns the erection of joint abattoirs is to be recommended.

"Veterinary surgeons have proved themselves excellent directors of official abattoirs.

"(17) In so far as the hygiene of meat is no special branch of examination for veterinary surgeons it should be introduced. To be admitted to the governmental examination (for veterinary surgeons) a certificate of having had an abattoir practice of at least a few months, for being appointed director of an abattoir, one of having had a practice of at least one year, is required.

"(18) It is desirable that the teaching relating to the hygiene of meat should be made more thorough in veterinary superior schools, and, at the same time, it would be necessary that veterinary students should have more opportunities of becoming familiarised with the technic and construction of abattoirs.

"THE METHODS EMPLOYED IN TREATING THE CARCASSES AND MEAT WITH THE OBJECT OF RENDERING THEM HARMLESS.

"(1) Flaying houses should be regulated by law, and placed under governmental control, with compulsory confiscation of the dead and other animals that must be rendered harmless. Certain standards should be introduced with regard to the smallest size of the animals.

"(2) The harmless destruction of carcasses and confiscated meat may only be done by combustion or in special apparatuses heated by steam.

"(3) For large abattoirs and flaying houses with apparatuses for destroying carcasses a system is to be chosen, that with a minimum of expense and simple manipulation assures complete sterilisation of the carcasses in such a way that the matter introduced leaves the apparatus in a finished state as a final product, and that the obtaining of valuable products is secured."

Barnes' views

W. G. Barnes, M.R.C.V.S.,[1] Chief Veterinary Inspector and Superintendent of Abattoirs, Metropolitan Meat Market, Islington, asks: "Is it not surprising, in this progressive age, that in the United Kingdom, where, in the subject of sanitation we are far in advance of other countries, as regards meat inspection we are far behind?

CAPTAIN W. GORDON BARNES, M.R.C.V.S., A.V.C.
Chief Veterinary Inspector and Superintendent Metropolitan Abattoirs, Corporation of London. Lecturer and Demonstrator on Meat and Food Inspection to the Sanitary Institute, Royal Army Medical Corps, Royal Veterinary College, University College, Army Service Corps.

"The Britisher is daily eating the flesh of diseased animals, and is unaware of it. He takes it for granted that the law of the country provides for the inspection of all butcher meat intended for his food, and consequently he does not deem it necessary to make further investigation into the matter, but is content to remain in ignorance of the fact that more than half of the meat consumed in this country is never seen by an inspector, and that in many parts of the country the system of meat inspection is scandalous.

"In many of our rural districts," Barnes continues, "meat inspection is a theory instead of a practice. It is not difficult to imagine such a state of affairs when we consider that the duties of meat inspection are left in the hands of the Inspector of Nuisances, whose multifarious duties are already more than he can conveniently cope with.

"There can be no gainsaying the fact that the system of meat inspection in this country is most unsatisfactory, and must continue so until those authorities responsible for public health ignore trade objections and vested interests, and make legislation under which the standard of inspection must be uniform throughout the whole country."

Slink meat trade

As illustrative of the methods of the slink meat trade, Barnes says ". . . . it is known that carcass butchers from towns some distance from London can afford to pay from 30s. to £2 more per head for a

1. Rept. of 26th Ann. Congress, Royal Sanitary Institute Belfast, 1911.

doubtful class of cattle, pay carriage to one of these places where there is little or no inspection, outside London, and then send the carcass to London for sale for human consumption; or, if it is too risky for sale in London, sell it locally. This can only have one meaning. Such a state of affairs is not only unfair and deceptive to the British public, but also unjust to the honest carcass butcher, who slaughters his cattle in a public abattoir, subject to scientific veterinary inspection, and who has to compete with the butcher whose cattle are not so subject.

"One must bear in mind that butchers are only human, and, however honest their intentions may be, if one of them is going to benefit to the extent of £16 to £26, by removing evidence of disease, he will risk the chance of ultimate discovery and conviction.

"With regard to live stock, many doubtful animals find their way into town markets, and the medical officers of health of the district from which the animals are sent notify the market officials of the fact. They, of course, in every case volunteer advice to the market officials to seize the animals; but why don't they seize them themselves, before they leave their own district, seeing that they are so empowered by the Public Health Acts? The reason is probably want of time, or are they incompetent to deal with the matter, and rather than disclose their inability, they let the matter drop, or notify the markets as above? Many medical officers of health candidly admit their inexperience, and agree that the control of the meat supply should be placed in the hands of the qualified and competent veterinary surgeons as in our Colonies and on the Continent.

Object of meat inspection

"The object of meat inspection is to prevent the sale and consumption of diseased, unsound, and unwholesome food; in other words, to protect the public where they are unable to protect themselves. Animals are subject to many diseases which affect the wholesomeness of their flesh as human food, the presence of which is not always discernible in the dressed carcass. Meat may carry the germs of the disease without giving any indication of the fact to the consumer, and whose detection is only possible to the expert. A pure meat supply can only be secured by an universal compulsory abattoir system, and general inspection of all animals intended for human food, also branding and marking of all meat.

"This system would afford the highest degree of protection to the consumer, and would probably be the indirect means of causing a great lessening in disease. Public health authorities are unanimous with regard to the advantages of branding meat intended for human food."

In a brief survey of our Public Health Acts, Barnes draws attention to the fact that the Scottish Act is the only one which gives the veterinary surgeon a legal standing, and reminds us that the French Government has called an International Conference to investigate the problems of meat branding and uniformity of inspection. "In the interests of the stock owners, traders, and the general public, the sooner such arrangements are made the better."

Dr. W. Hanna, D.P.H.,[1] Assistant Medical Officer of Health, Port of Liverpool, who also has large experience in these matters, confirms Barnes concerning the desirability of proper stamping of meat as regards its condition on slaughter, and that notwithstanding the stringent regulations in the countries exporting meat to these islands, constant supervision at the port of entry is necessary.

CREAM, BUTTER, BUTTERMILK, MARGARINE, CHEESE.

"The tubercle bacilli," says Jensen,[2] "are sufficiently resistant to live through the souring and other processes necessary in the manufacture of milk into butter and cheese, so that butter, as well as cheese, may contain tubercle bacilli. In some places this has been proven by a comparatively large number of butter tests."

Butter, buttermilk, margarine, cheese

Mohler[3] states that "The investigations of Rabinowitsch, Klein, Laser, Bang, Petri, Dawson, Markl, Möller, and many others have conclusively shown that tubercle bacilli may be present in butter, buttermilk, margarine, and cheese when these products are offered for sale."

Cream.—The Bureau of Animal Industry[4] pointed out that both the tendency of tubercle bacilli to rise with cream, and a comparison of European statistics relative to the frequency with which tubercle bacilli have been detected, respectively in milk and butter, indicate that when the bacilli are present in milk they will no doubt be present in greater concentration in cream and butter. Newsholme[5] confirms this for cream.

Margarine

Margarine.—"In oleomargarine," Schroeder[6] says, "tubercle bacilli may also remain alive long periods of time, probably as long as in butter, which it closely resembles in general character. In

Cheese

cheese the germs are especially dangerous when they occur in fresh products like cottage cheese; but that even those cheese which require some time to ripen are not wholly safe is shown by the fact that Professor F. C. Harrison proved that tubercle bacilli may remain alive in Cheddar cheese, a standard American variety, one hundred and four days."[7]

According to Mohler,[8] "In manufacturing margarine, the method commonly employed is to subject the finely comminuted fat to a

1. Rept. of 26th Ann. Congress, Royal Sanitary Institute, Belfast, 1911.
2. Milk Hygiene, p. 74.
3. P. H. and M. H. S., Bull. 56, pp. 507-8.
4. B. A. I. Circular 127, 1908, pp. 4, 5.
5. The Prevention of Tuberculosis, p. 145.
6. 25th Annual Rept. B. A. I., p. 147.
7. 19th Annual Rept. B. A. I., p. 228.
8. P. H. and M. H. S., Bull. 56, p. 509.

temperature not to exceed 122° Fah. for one and one-half hours. Sour milk is then added, and the whole mass is thoroughly mixed; dairy butter is next added, and a certain proportion of oils (cotton, palm, cocoanut, etc.). Enough of one or more of these oils is added to lower the melting point to that of dairy butter. Hence it will be seen that artificial butter thus made may be infected in three ways: first, from the fat secured from the original cattle, as tubercle bacilli will withstand a temperature of 122° Fah. for some hours; second, from the butter or soured milk that has been added; and third, from contamination during the course of its manufacture.

"Morgenroth made examinations of twenty samples of oleomargarine purchased in the open market, and proved the presence of virulent tubercle bacilli in nine of the specimens."

Cheese.—"In cheese also," Mohler continues, "tubercle bacilli may become mixed up with the curd during the process of manufacture, and they have been shown to remain virulent for over three months. As a result of Galtier's experiments conducted with cheese, both salted and not salted, which was found to contain tubercle bacilli when two months and ten days old, he concluded that coagulated milk, fresh cheese, and salted cheese made from the milk of tuberculous cows may infect man, and that the by-products fed to swine and chickens may infect these animals. In experiments made in Switzerland to determine the fate of tubercle bacilli in cheese, it was demonstrated that they died between the thirty-third and fortieth day in cheese made after the Emmenthal method, but considerably later in cheese made approximately after the Cheddar method. An emulsion of tubercle bacilli was added to milk at the same time as the rennet, and cheese was made from the milk in the manner required to obtain Cheddar cheese. From the time of manufacture average samples of the cheese were taken weekly, macerated in sterile water, and filtered. Guinea-pigs were inoculated with portions of the filtrate, and it was found that the germinating power of the tubercle bacilli lasted one hundred and four days, but after one hundred and eleven days they were incapable of conveying the disease to guinea-pigs by inoculation. Harrison concluded that these experiments justify the statement that Emmenthal cheese may be eaten with safety, as the period of ripening is much longer than the period during which the bacilli become innocuous. Cheddar cheese, he states, is seldom eaten under four months from time of manufacture, and during this period the tubercle bacilli lose their vitality. Notwithstanding this, however, the writer recommended the Pasteurisation of the milk in order to make the cheese absolutely safe. In a recent investigation, conducted by the writer in co-operation with Doane, tubercle bacilli have been demonstrated by guinea-pig inoculations in cheese one hundred and twenty-two days old made after the Cheddar method."

Cheese

Viability in cheese

Butter.—That infected butter may retain its virulence through several months has been adequately proved, according to Mohler,[1] by the Bureau of Animal Industry.

"In one series by Mohler, Washburn, and Rogers, three samples of butter were tested. The first was made from milk to which bovine tubercle bacilli had been added just before churning. They were obtained from a luxuriantly growing culture upon glycerin bouillon. Ten centigrams were removed from the surface growth of the flask, carefully mixed in a sterilised solution, and added to ten gallons of milk. The second sample was made from milk obtained from a cow affected with tuberculosis of the udder. In this milk tubercle bacilli of extreme virulence were present in great numbers. Both the first and second samples of butter were salted in the usual proportions of one ounce of salt to a pound of butter. The third sample was similar in every respect to the second, except that it was left unsalted. These samples of butter were tested upon guinea-pigs, not only when first made, but also after storing for ten days in the ice chest, after holding in cold storage for sixty days, and again after retention in cold storage for a period of five months (one hundred and fifty-three days). The results showed that each of these samples harboured virulent tubercle bacilli throughout the entire storage period, and that at any time they were capable of infecting guinea-pigs with tuberculosis if injected into the peritoneal cavity, and if the tuberculous butter was fed to the animals generalised cases of tuberculosis were still capable of being developed. In these experiments ten guinea-pigs were fed upon each butter sample for three consecutive days, and six were inoculated with the same kind of material. Six weeks later they were chloroformed and the visceral organs of each were carefully scrutinised that every trace of tuberculosis might be detected. None of the lots of guinea-pigs remained entirely free of tuberculosis, although those animals which were fed upon the contaminated butter failed to contract the disease as frequently as those which were injected. This experiment is to be extended farther in order to determine the maximum time in which infected butter, both salted and unsalted, will remain virulent when kept in cold storage under normal trade conditions. As the temperature in the cold storage rooms is very low, the evidence shows that the tubercle bacilli are held unchanged in the frozen butter for a long period, but that they slowly lose their vitality."

Experiments showing the long-retained virulence of tubercle bacilli in butter had been carried out at the Bethesda, Maryland, Station of the United States Bureau of Animal Industry.[2]

The results were adversely criticised from the popular point of view, because the tests were made by inoculating and not by feeding guinea-pigs.

1. P. H. and M. H. S., Bull. 56, p. 507.
2. Schroeder, 6th I. C. on T., Vol. 4, pt. 2, p. 604.

Tuberculous butter infects hogs

In reply to this criticism, the test was repeated by feeding to hogs. "Four hogs, weighing about 125 lbs. each, were tested with tuberculin to prove them free from tuberculosis, and were then confined in carefully disinfected pens and fed small amounts of butter made from the milk of a cow affected with udder tuberculosis.

"Two of the hogs were fed butter salted at the rate of one ounce of salt to the pound of butter, and two received unsalted butter.

"At the time the butter was fed it was three months old or older; each hog received one ounce daily, and the feeding was continued one month, so that each hog received in the course of the month, in addition to its regular food, a little less than two pounds of butter, that is, probably a smaller amount than is usually eaten by persons of the same weight.

"Several months after the feeding the hogs were killed and examined *post mortem*, and the two that had eaten the salted, and one of the two that had eaten the unsalted, butter were found to be affected with tuberculosis.

"Several hogs kept under the same conditions as the foregoing, without being fed infected butter, were found, when killed and examined after death, to be free from tuberculosis."

Schroeder[1] says: "In ordinary salted butter tubercle bacilli remain alive and retain their virulence one hundred and sixty days or longer, and show no positively determinable loss of virulence in ninety days, or three months. Mohler, of the United States Bureau of Animal Industry, Division of Pathology, proved that tubercle bacilli remain alive and virulent in butter, kept under ordinary commercial conditions, at least one hundred and fifty-three days."

Chicago regulations

In Chicago, U.S.A., [2]"It is made unlawful, under penalty of confiscation, to sell....butter or cheese which does not bear upon the package either the words 'Made of milk (or cream) from cows free from tuberculosis as shown by tuberculin test,' or the words 'Made from milk (or cream) Pasteurised according to the rules and regulations of the Department of Health of the City of Chicago.'"

"We may conclude," says Schroeder,[3] "as far as it is possible to test the vitality and virulence of tubercle bacilli from different sources and in different environments, that those from cattle are as a rule the most virulent, and that it seems clear that dairy products generally, and butter especially, supply an ideal medium for the preservation of both the life and the virulence of tubercle bacilli."

Dawson[4] "....claims to have produced tuberculosis in a guinea-pig by inoculating it with butter eight months old." Schroeder confirms this figure.[5]

1. 6th I. C. on T., Vol. 4, pt. 2, p. 603.
2. Dr. Eastwood's Rept., p. 40.
3. B. A. I. Annual Rept., p. 147.
4. 6th I. C. on T., Vol. 4, pt. 2, pp. 736, 737.
5. B. A. I. Annual Rept., p. 146.

CHAPTER IV.

WHAT IS THE EXTENT OF THE DANGER OF BOVINE TUBERCULOSIS TO MAN ?

MILK AS A CAUSATIVE AGENT IN HUMAN TUBERCULOSIS.

In the present state of our knowledge no definite answer can be given to this important question. One can only form an opinion by weighing the possibilities and probabilities. The share of responsibility chargeable to milk can be best judged by reviewing the sources from which human beings contract tuberculosis. We shall, therefore, glance at these sources in the hope that milk will naturally fall into its proper place.

Congenital Tuberculosis.—" The direct transmission of tuberculosis from parent to child," says Newsholme,[1] " may occur before birth, either germinally—a very rare phenomenon—or during intra-uterine life, a more common, but still rare, event.

" The passage of the tubercle bacillus through the placental tissues to the fœtus has been proved by a number of pathologists. Thus, Johne found tubercles in the lungs and bronchial glands of the eight months' fœtus of a tuberculous cow. M'Fadyean found cheesy foci in the liver and portal glands of a five days old calf. Similar cases have been described in the human fœtus.[2] Fränkel (1906) thinks that the danger of hæmatogenous[3] infection through the placenta is commonly understated. He quotes Schmorl, who found tuberculous nodules in nine out of 20, or 45 per cent., of the placentas of tuberculous women examined by him, and these were found not only in cases of miliary tuberculosis or advanced phthisis, but also in a case of incipient phthisis. It is possible, furthermore, that the instances in which obvious tuberculous lesions are found in the new-born child do not cover the entire ground. Other infants may have latent tuberculosis, which develops into obvious disease later in life.

" This view is commonly associated with the name of Baumgarten, though it was held before his day. He believes that either germinal or intra-uterine transmission of infection is the most common cause of tuberculosis, and that long latency of the infection is the rule rather than the exception. He goes farther, believing even that a person may have been infected by transmission through two generations from a tuberculous grandparent.

1. The Prevention of Tuberculosis, p. 182.
2. " The countless opportunities afforded by *post mortem* examination of young children have not yet led to the detection of 50 cases of congenital tuberculosis in the human species."—Prof. Sir John M'Fadyean, Jour. R. A. S. E., Vol. 71, p. 31.
3. " Hæmatogenous "—conveyed by the blood stream.

"The views of Baumgarten, apart from the last-named point, are supported by the fact that microscopic examination of the liver and inoculation experiments with fœtal tissues showing no naked-eye evidence of disease have occasionally shown the presence of tubercle bacilli. Baumgarten considers long dormancy of tubercle bacilli in lymphatic glands, the medulla of bone, etc., as common, the young tissues of growing animals having special resisting power against the bacilli. His view involves the unlikely supposition that a very large part of the human race carry within them tubercle bacilli at birth. At the same time, the analogous case of congenital syphilis, with long latency of an infection acquired before birth, indicates that congenital tuberculosis is within the range of possibility. It is possible, as J. K. Fowler has suggested, that evidence will accumulate in favour of the view that sometimes tuberculosis of the glands, joints, and bones in children may have been transmitted from the parent and remained dormant for several years. To prove such cases it would be necessary to show that the mother was tuberculous, and that there had been no exposure to infection after birth. In the absence of evidence on the latter point, either the ordinary view of infection after birth, or the view that infection was acquired before birth, would be tenable.

"The fact that visible tuberculosis is more commonly found with each additional month after birth may be explained either on the supposition that early life tuberculosis is in the main acquired after birth, or by assuming that ante-natal tuberculosis remains long latent so far as symptoms are concerned.....

"**Hereditary Predisposition.**—Phthisis is usually regarded as a typically hereditary disease, in the causation of which family predisposition plays a large part. The extent to which heredity is held to operate has diminished as our knowledge of the causation of tuberculosis has become more exact. The most prevalent view is contained in the following statement by Drs. C. J. B. and C. Theodore Williams.

"'Family predisposition has, by general consent, held a very prominent place, but the value of its influence in the causation of phthisis has been modified of late years by the fuller recognition of other causes which had been to some extent overlooked—such as damp, inflammatory attacks, etc. These and other direct sources of phthisis must exercise in our calculations a depreciatory influence on the amount we assign to hereditary transmission, and numerous cases of this disease, which have hitherto been held to originate in a consumptive ancestry, will now be traced to a nearer and more direct cause. Nevertheless, no small number of cases owe their origin to hereditary predisposition, though it is not always easy to demonstrate their hereditary character. Its exact value as a predisposing agent, its mode of transmission, the varieties of the disease in which its influence is most apparent—all these and other points of interest are by no means settled questions, but still open to further inquiry.'

"Similarly, Dr. S. West[1] states that 'recent additions to our knowledge of tuberculosis have greatly modified the views held as to the influence of inheritance in phthisis'; but after giving statistics he concludes that 'family predisposition is an essential factor in phthisis, though probably not exerting so important an influence as has been hitherto believed.'"

Newsholme shows that the process of reasoning upon which the belief in hereditary predisposition as an important factor in the causation of phthisis is based will, just as readily, serve to prove hereditary predisposition in the case of scarlet fever.

Professor Sir John M'Fadyean[2] points out that "The belief that tuberculosis is frequently inherited dates from a time when it was not known, and for the most part not even suspected, that the disease was caused by a germ or bacterium, and hence in the first instance it was supposed to be the predisposition or susceptibility that was transmitted from the tuberculous parent to the offspring..... A fact which everywhere forced itself upon attention was that the disease among human beings often ran in families; and quite naturally, since there was no suspicion that the disease was contagious, this fact was ascribed to the hereditary transmission of the peculiar weakness which was regarded as the main factor in the causation of tuberculosis. The question, of course, assumed an entirely new aspect when Koch discovered the tubercle bacillus, and proved that the essence of the disease was the introduction of this organism into the previously healthy body.....[3]But since consumption is now universally admitted to be a contagious disease, it is obvious that this fact may admit of another explanation, viz. that exceptional risks of infection, and not exceptional susceptibility transmitted by a parent to offspring, may be at the root of family tuberculosis. In the case of human beings, tuberculous parents, in the immense majority of cases, inhabit the same houses and even the same rooms as their children, and hence as a rule such children are exposed to a great risk, against which until recently no precautions whatever were taken.

"When full weight is allowed to this consideration there does not appear to be any reason to assume the existence of a special predisposition to account for the fact that human tuberculosis tends to run in families.....[4]At the present day, therefore, it must be denied that the existence of family predisposition is proved by the fact that cases of tuberculosis are more frequent among the children of tuberculous parents than among those whose parents are healthy. An attempt, however, is sometimes made to reconcile belief in the importance of inherited special predisposition with the fact that tuberculosis is a contagious disease (1) by assuming that in civilised

1. Diseases of the Organs of Respiration, 1902, Vol. 2, p. 449.
2. Jour. R. A. S. E., 1910, p. 27.
3. Jour. R. A. S. E., 1910, p. 33.
4. Jour. R. A. S. E., 1910, p. 34.

communities the tubercle bacillus is so widely distributed that everyone is constantly or frequently exposed to risk of infection, and (2) by citing cases in which various members of the same family have in succession developed tuberculosis long after separation from the diseased parent and from each other.

"But the assumption that the tubercle bacillus is ubiquitous is opposed to a great mass of experimental evidence. It is true that since no restrictions are placed on the movements of tuberculous human beings no one can escape all risk of infection, but the average risk attributable to this circumstance is nothing like so great as the risk to which those are subjected who from the day of their birth live in close association with their already diseased parents.

"As to the late development of tuberculosis by persons long after their removal from what may be called the consumptive household, it must be observed that the fact is explainable without calling in the agency of inherited special predisposition. It is a fallacy to assume that in such cases the late development of the disease means a late infection, for there is clear evidence to show that infection in early life may not be manifested by outward symptoms until long afterwards, and, indeed, may never be followed by actual illness at all.

"The whole question in connection with the alleged inheritance of a special predisposition may be summed up by saying that there is no evidence to prove that such inheritance plays a part of any importance in determining the incidence of tuberculosis in the human species, and that all the observed facts can be reasonably accounted for without assuming that susceptibility to tuberculous infection varies much from family to family."

We are thus confronted with the question whether the great source of human tuberculosis is

"**Hereditary Predisposition or Infection.**—It is easy to prove heredity," Newsholme[1] points out, "in the case of a disease like hæmophilia,[2] where (*a*) the disease is rare and presumably not infectious, and (*b*) either all or almost all the cases occur among those whose ancestors had the same disease. But in phthisis we have to deal with a disease which, in the first place, is infectious, and would, therefore, give no such clear evidence of heredity, even if heredity were potent; and which, in the second place, is very common, causing in the general community about one out of every twelve male and one out of every seventeen female deaths from all causes. Since it is infectious, one cannot expect all the cases to be limited to families with hereditary taint, however strong this influence may be, and in actual fact it is not so limited. Finally, even if it be shown that the number of adult deaths from phthisis amongst those with a tuberculous

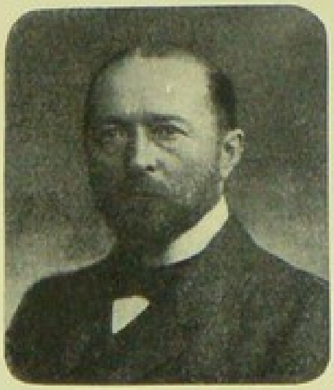
1. The Prevention of Tuberculosis, p. 186.
2. "Hæmophilia"—an hereditary disease manifested by excessive bleeding from slight injuries, or even spontaneously; sometimes fatal.

family history is in that class much greater than the number among a corresponding number of the general population similarly situated as to age and sex, it does not necessarily follow that this is due to hereditary predisposition. It may result from greater exposure to infection. There cannot be said to exist satisfactory data enabling this doubt to be cleared up.....On the whole," Newsholme concludes, "we shall probably not err greatly if we agree with Koch's statement that 'great importance used to be attached to the hereditary transmission of tuberculosis. Now, however, it has been demonstrated by thorough investigation that, though hereditary tuberculosis is not absolutely non-existent, it is, nevertheless, extremely rare, and we are at liberty, in considering our practical measures, to leave this form of origination entirely out of account.'

"**The Practical Aspects of Heredity in Tuberculosis.**—The statement last quoted from Koch must command particular approval when considered in relation to administrative measures. From the standpoint of practical public health administration, if it were ultimately to be established that heredity exercises a greater effect on the transmission of tuberculosis than has hitherto been attributed to it, the measures of precaution indicated by this result might be increased in number, but none of those of which the adoption is recommended on other grounds would become more safely negligible than they are now considered to be."

Infection not heredity is the cause

It thus becomes clear that the great source of human tuberculosis must be traced in the life of the individual. In other words, it is a matter of infection, or, as Letulle and Rey[1] have it, "The consumptive is made, not born." How does this infection occur, and what is the source of it?



HIS EXCELLENCY PROF. DR. EMIL. VON BEHRING
Imperial German Privy Councillor, Director of the Hygienic Institute of Marburg University.

Infection by Inhalation.—The fact that by far the greater proportion of human tuberculosis found in the lungs (consumption) naturally gave rise to the belief that infection was conveyed by bacilli breathed into the lungs (inhalation).

This belief held undisputed sway until the advent of

VON BEHRING'S THEORY OF INFECTION FROM MILK DURING CHILDHOOD.

When one remembers that "....persons and dairy cows," as pointed out by Schroeder,[2] "are the commonest subjects of tuberculosis," and that the chances of infection from bovines to man are frequent, owing to our consumption of dairy products which have not been heated or cooked in any way, von Behring's theory would seem,

1. 6th I. C. on T., Special Vol., p. 230.
2. P. H. and M. H. S., Bull. 56, p. 530.

on the face of it, a very probable one. This thesis is contained in his words: "I believe I have discovered a new principle which may be expressed thus: The milk fed to infants is the chief cause of consumption."[1]

The tubercle bacilli in tuberculous milk were believed to pass through the wall of the intestine without leaving wound or other trace to mark their passage. They would then take up their abode in some abdominal gland structure and remain inactive, perhaps for many years; at a later period becoming active at some inopportune moment when, through illness or otherwise, the resisting powers of the individual had been temporarily lowered.

Calmette[2] says "We now know that this view is much too sweeping, and finds contradiction in a mass of clinical and experimental facts. It is, indeed, as untenable as the opposite view, advanced by Robert Koch, that tubercle bacilli of bovine origin are entirely innocuous to man."

Von Behring's theory rejected

Newsholme[3] accepts the findings of the British Royal Commission of 1898, confirming the opinion of the previous Royal Commission, that "....no doubt the largest part of the tuberculosis which man obtains through his food is by means of milk containing tuberculous matter."

Dr. Adolf von Baumel[4] concludes, "In most cases tuberculosis begins in the first year of life."

Infection during childhood

Letulle and Rey[5] state that "The tuberculosis which appears in the adult is, in most cases, prepared in advance by an attack which the individual has had during his neglected infancy." Dr. Nathan Raw[6] concurs in this.

Professor O. Medin, M.D.,[7] of Stockholm, found that among 400 infants tested with tuberculin (von Pirquet's test, see p. 254) only 2·5 per cent. reacted. He considers this fact of great importance, and points out that "We do not find nearly so many tuberculous individuals among infants under one year of age as we do among older children, and this tends to confirm my opinion," Medin continues, "that tuberculosis is not often conveyed to children during their earliest infancy, to become latent and break out at some future time."

Bang[8] believes we are "....justified in concluding that more than one half of the tuberculous human beings were infected in childhood," and that of the 48 per cent. of cattle in adult age that

1. Von Behring, The Suppression of Tuberculosis, Veterinary Congress in Cassel, Sept., 1903, American translation, p. 31. London, Chapman & Hall.
2. 6th I. C. on T., Special Vol., p. 66.
3. The Prevention of Tuberculosis, p. 406.
4. 6th I. C. on T., Vol. 2, p. 606.
5. 6th I. C. on T., Special Vol., p. 230.
6. See The Clinical Journal, Aug. 23rd, 1911, p. 319.
7. 6th I. C. on T., Vol. 2, p. 387.
8. 6th I. C. on T., Special Vol., p. 218.

he found suffering from tuberculosis, the majority were infected at the age of two years. Bang emphasises the necessity of protecting young individuals, bovine and human, from infection. This distinguished observer makes an interesting comparison between the figures he obtained among bovines and those found by Nägeli for human beings.

Bang found among 40,624 cattle tested with tuberculin for the first time

	Per cent.	
Calves up to six months ..	12·1	reacted.
Yearlings ..	27·5	,,
Two-year-olds ..	38·6	,,
Adult animals above 5 years	44·9	,,

Nägeli found the following percentages of tuberculosis among human beings.

	Per cent.
Of 1 to 5 years ..	17
,, 5 ,, 14 ,, ..	33
,, 14 ,, 18 ,, ..	50
,, 18 ,, 30 ,, ..	96

Park[1] quotes the statistics collected by Dr. Flick: "Of 1,206 persons suffering from tuberculosis, attending the Phipps Institute, 1,103, or over 90 per cent., were breast fed." Manifestly, these had not been infected by cow's milk in early infancy.

The student finds his views confronted at this point with the rival theories of "Ingestion" and "Inhalation," the adherents of the former view claiming that the prevalence of the disease in the lungs is no proof that the organism gained entrance with the breath, but that having reached the blood stream through the walls of the alimentary tract it would be filtered out by the lungs, hence the frequency of infection of that organ.

IS HUMAN TUBERCULOSIS CONTRACTED BY BREATHING OR SWALLOWING ?

A vast amount of discussion has been expended on this subject among pathologists. It is obviously of prime importance in tracing the source of infection, therefore within the scope of our present inquiry; for if the virus of the disease is taken in with the breath the suspicion against milk fails.

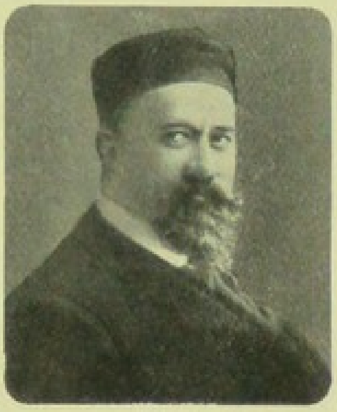
The investigators who believed that infection was conveyed by swallowing had to account for the most important fact that the lungs were the most frequently affected part in human beings. How to connect the food with the lungs was the problem.

The ingestion theory

Schroeder[2] explains it as follows: "The normal channel through which solid material from without enters the body is the digestive canal. It has been shown by Nicolas and Descos, by Ravenel, by Schloszmann and Engle, by Calmette and his associates, and by other bacteriologists and pathologists too numerous to mention, that tubercle bacilli may penetrate rapidly through the healthy walls of the intestines and reach the great thoracic lymph duct. The thoracic

1. 6th I. C. on T., Vol. 1, pt. 1, p. 160.
2. 25th Annual Rept. B. A. I., p. 152.

duct empties its contents into one of the large veins that communicate with the heart; mixed with the blood in this vein the material from the duct enters the heart, and is pumped directly to the lung, where it is filtered through the lung capillaries, which are the finest and most complex capillaries of the body. If we recall that the careful anatomical examinations made by Aufrecht and by Calmette and his associates proved that the tuberculous processes in the lungs have their beginning in the finer lung capillaries and not in the finer air tubes, we are in a position to conclude that infected food, much more than infected air, is to be dreaded as a cause of tuberculosis."



PROFESSOR D. A. CALMETTE
Director of the Pasteur Institute, Lille, France.

Mohler[1] believes this explains probably the chief mode of infection, especially in animal tuberculosis, and that its correctness is supported in a great number of instances by numerous careful experiments.

Newsholme[2] points out the important natural obstacles to the inhalation of foreign particles, even so small as bacteria, as follow:—

"(1) *The Complexity and Shape of the Respiratory Passages.*—Angles are met with in the nostrils, nasal cavity, pharynx, glottis, trachea, and bronchi, and at every successive angle the inhaled dust is filtered off. With quiet breathing the greater part is stopped in the nostrils.

"(2) *The High Reflex Irritability of the Nasal and Pharyngeal Mucous Membrane.*—The irritation produced by the presence of foreign particles may be so great as to cause sneezing and consequent expulsion of the offending particles, together with others too small to offend.

"(3) *The respiratory passages* are lined with a *coat of mucous*, and the individual *cells are provided with cilia* flicking all particles upwards towards the outlet. By this means a steady flow of mucous towards the pharynx is maintained, and a similar flow along the nose. Accumulated dust is thus swept into a position from which it can readily be ejected."

Newsholme adds the experimental evidence of St. Clair Thomson and Hewlett[3] (1895) having ascertained that at least 1,500 organisms are inhaled into the nose every hour, and that in London it must be common for 14,000 to enter in an hour of quiet breathing, nevertheless found that the interior of the great majority of normal nasal cavities is perfectly aseptic.[4] They also confirmed Hildebrandt's experiments

1. 25th Annual Rept. B. A. I., p. 156.
2. The Prevention of Tuberculosis, p. 107.
3. Path. Soc. Trans., Vol. 78; quoted by Newsholme, The Prevention of Tuberculosis, p. 110.
4. "Aseptic"—free from bacteria.

made in 1888, in several instances the trachea of animals killed in the laboratory being found on opening to be free from bacteria.

Professor Sir John M'Fadyean[1] tells us that " Sir William Whitla, who in 1908 delivered the Cavendish Lecture before the West London Medico-Chirurgical Society, chose as the subject of his address, ' The Etiology of Pulmonary Tuberculosis,'[2] and sought to show that recent researches had completely overthrown the previously accepted view that inhalation is the common method of infection in man. In the course of his address he outlined the researches of Calmette and Guérin, and Vansteenberghe and Grysez, regarding tuberculosis and pulmonary anthracosis, and adopted the conclusions of these authors with enthusiasm. He characterised the experiments of Calmette and Guerin as epoch-marking, declared that they had shifted the question of the portal of entrance of the tubercle bacillus from the site of pulmonary alveoli to that of the intestinal epithelium, and prophesied that probably at no distant date it would be accepted that ' in the immense majority of cases pulmonary tuberculosis is not contracted by inhalation, but, as taught by von Behring, the germs enter through the intestinal tract.' In support of this view he described certain experiments which he had carried out in conjunction with Professor Symmers regarding the production of pulmonary anthracosis. The results of these experiments were in complete accord with those obtained by Vansteenberghe and Grysez, in that more or less marked pigmentation of the lungs was found in adult guinea-pigs into whose stomachs large quantities of Chinese ink had been introduced even as short a time as four hours before they were killed. In some cases the animals' lungs exhibited ' an almost ebony-like blackness.' "

Schroeder[3] confirms Newsholme's views regarding the improbability of infectious dust gaining access to the lungs by inspiration. He points out the great difficulty in pulverising dried sputum to a powder so fine that it would remain suspended in the air current passing through the long, narrow, tortuous, moist-walled system of channels to the lungs, and thinks it should "....readily be seen that the inhalation theory to account for the infection of the lung is simple only when we fail to analyse it, and that analysis shows it to be a practically impossible hypothesis."

Raw,[4] on the contrary, whom one cannot doubt *has* analysed the hypothesis, believes that the "....evidence is overwhelming in favour of aerial infection due to the inhalation of dried sputum in overcrowded and badly ventilated dwellings."

Raw also attaches special importance to direct contact with the consumptive, as in kissing.

1. Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 300.
2. British Med. Jour., 1908, p. 61.
3. 25th Annual Rept. B. A. I., p. 144.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 784.

Inhalation or ingestion

Oettinger[1] argued that if lung filtration is the correct explanation, bacteria introduced into the blood should be found intercepted in the lungs. As a result of experiment, he does not find this is the case; but that the bacteria are to be found mostly in the liver. He maintains, therefore, that when bacilli are found in the lungs, and not in the other organs, the presumption is that they have been inhaled and not that they have arrived there from the blood.

Permeability of intestinal wall

Reichenbach and Bock[2] discuss the experiments which it is claimed prove the permeability of the intestine towards the tubercle bacillus. These investigators reject the said results on the ground that the experiments were performed under unnatural conditions. The bacilli, they contend, have been given in huge doses, or the blood vessels have been opened up in making an artificial gastrotomy,[3] or the intestines have been injured by large doses of purgatives, or the animals had been starved for a long time. Having eliminated all these sources of error, and used quantities of bacilli which were accurately estimated, they conclude that the alimentary canal is not permeable to the tubercle bacillus, and that this fact is the only satisfactory explanation of the vast discrepancy between the feeding and breathing doses necessary to produce infection.

Reichenbach studied the relative experimental probability of alimentary and inhalation infection by tubercle bacilli. After making corrections of the bacilli which, in such experiments, are really not inhaled, and for those which never really reach the lungs, he arrived at the conclusion that 367,000 times the inhalation dose is required to produce an alimentary infection in guinea-pigs; while, in the case of goats, at least 500 times as many bacilli were required to produce infection by feeding than by inhalation.[4]

THE EVIDENCE AFFORDED BY PULMONARY ANTHRACOSIS.

"It is a familiar fact," says Sir John M'Fadyean,[5] "that both in men and animals which have for any considerable period lived in a smoky atmosphere the lung tissue and the bronchial glands are often visibly pigmented with carbon particles.

"Prior to the year 1905 it was generally accepted that the pigment was composed of soot particles which had been suspended in the atmosphere and had reached the lung tissue direct with the inhaled air. The pigmentation of the glands was ascribed to the transport of the same soot particles from the lung tissue by way of the lymphatic vessels.

1. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 7.
2. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," p. 7.
3. "Gastrotomy"—the operation of making an artificial opening into the stomach, usually with the object of introducing food.
4. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 7.
5. Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 299.

"Very little reflection will show that, as part of the case put forward by Calmette and others in favour of the intestinal origin of pulmonary tuberculosis, it was necessary to show that this view of the genesis of anthracosis of the lungs and bronchial glands was erroneous. At Calmette's suggestion, the question was experimentally investigated by Vansteenberghe and Grysez,[1] and as a result they maintained that the easiest method of producing a typical pulmonary anthracosis in adult guinea-pigs consisted in mixing Chinese ink or carbon powder with their food. They declared that when the animals were killed twenty-four hours after such a repast the pulmonary parenchyma showed disseminated black spots, especially in the upper lobes and along the edges of the lower lobes. In these cases the mesenteric glands were normal, but those of the mediastinum were swollen and black.

"They found that when young guinea-pigs were used for experiment the results were completely different, inasmuch as the lungs showed no pigment, while the mesenteric glands were absolutely infiltrated with carbon particles.

"In support of their contention that pulmonary anthracosis is due to intestinal absorption of the pigment, they also reported that when the esophagus had previously been ligatured pigmentation of the lungs could not be produced by causing the animals to inhale a smoky atmosphere except when the experiment was very prolonged.

"As was to be expected, these statements attracted much attention, and quite a large number of experiments were soon afterwards carried out by various observers[2] in order to determine whether the new view put forward regarding the intestinal origin of pulmonary anthracosis was correct or not."

Referring to the above-mentioned experiment of Vansteenberghe and Grysez, Newsholme[3] reminds us that "Schultze[4] (1906) repeated these feeding experiments with similar results; but he is convinced that in feeding experiments, even when undertaken with the aid of a tube, inhalation cannot be excluded, and he explains in this way the deposit in the lungs. That this may be the correct explanation is supported by the fact that in a rabbit having a gastric fistula,[5] through which he introduced pigments into the stomach daily for two months, no deposit was found *post mortem* in the lungs."

Kolisch[6] concluded that infection from inhaled dust is possible under certain conditions; namely, dryness of the dust and inhalation of very large quantities.

1. Annales de l'Institut Pasteur, 1905, p. 787.
2. Newsholme especially mentions Villoret in this connection. See Prevention of Tuberculosis, p. 111.
3. The Prevention of Tuberculosis, p. 111.
4. Münch. med. Woch., 53, 1902.
5. "Fistula"—a pipe-like sore with a narrow orifice and without disposition to heal.
6. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 7.

"Zenker (quoted by Arlidge)[1] produced red colouring of the substance of the lungs of animals by causing them to inhale a red dust, and Knauff (quoted by Buck),[2] after inhaling particles of ultramarine for only ten minutes, found that the cells of his expectoration contained blue particles in their interior. In ultramarine workers the coloured dust has been recognised in expectoration fourteen days after cessation from work. Rabbits confined in a smoky atmosphere can be shown to have fine particles of carbon in their bronchi. Knauff (quoted by Greenhow)[3] placed dogs for from one day to three months in a roomy chest, into which the fumes of a smoking oil lamp were conveyed by a flue opening through the floor. One dog killed after a single day in the smoke chest had the whole surface of the bronchial mucous membrane, even to the alveoli of the lungs, covered with a deposit of carbon mixed with mucous. Animals kept there for some weeks showed similar deposits throughout the lungs; the lymphatic glands were very early affected. In animals confined for several weeks in the experimental chest there was almost invariably a deposit of carbon below the pleura. Control animals showed no similar appearances."

Referring to the work of St. Clair Thomson and Hewlett, Hildebrandt, Zenker, and Knauff, Newsholme points out that "....none of these experiments is quite inconsistent with the view that the particles of pigment had been swallowed and reached the lungs by means of the lymph stream."

One observes the neutral attitude taken up by many competent authorities as a result of such work as that described above; thus, Newsholme[4] considers "It cannot be regarded as settled to what degree human tuberculosis is due to direct inhalation into the lungs, to entrance of infective material through the tonsils, etc., and to intestinal infection. Much less is this point settled for pulmonary tuberculosis."

Bartel[5] admits that it is difficult to judge the relative effects of deglutition and aspiration to settle the constant dispute concerning the more frequent mode of infection, whether due to swallowing or inhalation.

Park[6] agrees that the paths by which tubercle bacilli gain entrance into the human organism is a point still disputed and "under investigation."

Dr. A. G. Anderson[7] does not appear to accept either theory as sufficient. "In the present state of our knowledge," he says, "it

1. Diseases of Occupations, p. 246; quoted by Newsholme, "The Prevention of Tuberculosis," p. 110.
2. Manual of Hygiene and Public Health, Vol. 2, p. 29.
3. Path. Trans., Vol. 20, p. 57.
4. Prevention of Tuberculosis, p. 120.
5. 6th I. C. on T., Vol. 1, pt. 1, p. 100.
6. 6th I. C. on T., Vol. 1, pt. 1, p. 157.
7. Dr. Anderson's Rept., p. 29.

appears that while we are not justified in accepting von Behring's theory in its entirety—especially as regards consumption in the adult being always due to infection from milk in infancy—the older theory that infection always took place by breathing must now be considered no longer tenable, and must be greatly modified. The accumulating evidence that the bovine type of bacillus (the bacillus found in tubercular milk) is so often discovered in children suffering from tuberculosis of the bowel and abdominal glands, as well as the large amount of experimental evidence, not only strongly supports the ingestion theory, but further clearly points out the direction for administrative measures." We now believe "....that tubercular infection through the ingestion of tubercular milk must receive more serious and practical consideration than heretofore."[1]

Kuss[2] suggests that "One must take an impartial view of the whole problem, and be willing to agree that both channels of infection are open. In animals, however, the alimentary tract seems to be a more common port of entry."

"It seems to me," says Bang,[3] "that, interesting as the questions are in themselves, it is of no great importance, in relation to the prophylaxis, to know which method of infection the bacilli most frequently employ. It is the close association with individuals with 'open tuberculosis' that is so dangerous, whether the secreted bacilli are inhaled by the healthy animals or human beings, or admitted through the mouth after having fallen on their food or drink."

For the purpose of our present inquiry, however, the question *is* of importance, as we are mainly interested in the study of the part played by milk as a vehicle of infection, rather than the prophylaxis of tuberculosis.

M'Fadyean[4] trenchantly discusses the question in rejecting the views propounded by Calmette and his supporters that infection in inhalation experiments is really due to swallowing a few of the bacilli. He points out that if *all* the bacilli conveyed in spray form were swallowed by the experimental animals, infection would not occur, so that it is [5]"....ridiculous to suppose that the small proportion of the sprayed material accidentally swallowed could be held accountable for the animals' infection."

Our eminent authority also quotes the experiments of Findel,[6] Alexander,[7] Kossel, Weber, and Heuss,[8] and Weber and Titze,[9] in all of which the marked susceptibility to air-borne bacilli is shown for

1. Dr. Anderson's Rept., p. 3.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 111.
3. 6th I. C. on T., Special Vol., p. 213.
4. Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 289.
5. Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 290.
6. Zeit. f. Hyg., Vol. 57, p. 104.
7. Zeit. f. Hyg., Vol. 60, p. 467.
8. Tuberkulose-Arbeiten aus dem Kaiserlichen Gesundheitsamte, 3 Heft, 1905.
9. Tuberkulose-Arbeiten aus dem Kaiserlichen Gesundheitsamte, 10 Heft, 1910.

guinea-pigs, rabbits, calves, goats, dogs, and oxen, as compared with bacilli mixed with the food.

Regarding the work of Vansteenberghe and Grysez,[1] who maintained that the easiest method of introducing particles of carbon (Chinese ink or soot) into the lung tissue of an animal was to mix the material with the food, it is pointed out that Beitzke[2] repeated the experiments and obtained diametrically opposite results. "He upheld the older view as to the respiratory origin of pulmonary anthracosis, and contended that when the condition was found in animals experimentally fed with carbon mixtures, the result was due to aspiration of the mixture during feeding. When precautions were taken to prevent this accident, pulmonary anthracosis was never found in the experimental animals."

"Kuss and Lobstein[3] found that it was possible," says Sir John M'Fadyean, "to produce pigmentation of the lungs and bronchial glands by causing animals to inhale carbon for twenty minutes morning and evening for three weeks. In their experiments it was found that when the same quantity of Chinese ink was administered to some animals by inhalation, and to others by ingestion, only the former showed anthracosis. It is true that they found that when massive doses of Chinese ink were introduced directly into the stomach, or into the duodenum, one might find in the animals killed from twelve to thirty hours afterwards some small sub-pleural points of pigmentation, but in order to produce a condition comparable with natural anthracosis it was necessary to inundate the intestine with Chinese ink. They therefore concluded that the ordinarily observed anthracosis is ascribable to inhalation, and not to deglutition.

"Nieuwenhuyse,[4] as the result of experiments carried out on thirty-five guinea-pigs, concluded that pulmonary anthracosis is not of intestinal origin.

"Arloing and Forgeot[5] carried out experiments bearing on this question with guinea-pigs, rabbits, goats, and dogs (young and adult), which were given by ingestion Chinese ink, charcoal, or pigment from a melanotic tumour in a horse. The animals were killed from six to forty hours afterwards. In no case did they find any anthracosis of the intestinal wall or mesenteric glands. They concluded that if such solid particles do ever transverse the intestine, it can only be in exceptional cases and not under physiological conditions."

Ballin[6] also rejected the theories of the Lille School after his

1. Annales de l'Institut Pasteur, 1905, p. 787; quoted by M'Fadyean, Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, p. 299.
2. Virchow's Archiv., Vol. 187, p. 183.
3. C. R. Acad. des Sciences, Vol. 144, p. 162, and C. R. Soc. Biologie, Vol. 62, p. 139; quoted by M'Fadyean, Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, p. 300.
4. Reference in Bulletin de l'Institut Pasteur, 1907, p. 472.
5. C. R. Acad. des Sciences, Vol. 144, p. 786.
6. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 7.

experiments with the spores of easily recognisable moulds, which were blown into the air and breathed by guinea-pigs killed at intervals after the inhalation. Ballin found that the spores were discoverable in the alveoli, smaller bronchioles and alveolar walls of the lungs, thus indicating that they had been air borne, therefore inspired, and not derived from the alimentary tract. Animals were also fed with large quantities of the spores, yet none of the latter could be found in the lungs.

In reference to anthracosis and the experiments of Whitla and Symmers, Sir John M'Fadyean[1] says, "Before attempting to explain the results of these experiments it may be observed that even if they admitted of no other explanation than the one put forward by Sir William Whitla, viz. that the carbon particles had reached the lung tissue from the intestine by way of the thoracic duct, they could not be accepted as proof that the tubercle bacilli which cause pulmonary tuberculosis reach the lung by the same route, in view of the results obtained by Findel, Reichenbach, Alexander, Heymann, and others, in the experiments to which I have already referred.

"It may, however, with some confidence be suggested that Whitla and Symmers, as well as Vansteenberghe and Grysez, have misinterpreted their results, through failing to take account of certain possibilities of error involved in their method of experimentation.

"In the first place it must be noted that they appear to have neglected the possibility that the anthracosis which they found in their experimental animals was spontaneous. The force of this suggestion will appeal to any one who has paid attention to the frequency with which pulmonary anthracosis is found in healthy adult guinea-pigs. It is true that 'almost ebony-like blackness' of the lungs from spontaneous anthracosis is never found in guinea-pigs; and if Whitla and Symmers found such a condition in guinea-pigs which simply ingested food mixed with Chinese ink I, for one, must declare myself unable to offer any certain explanation of the occurrence. At any rate, the authors' explanation cannot be accepted as reasonable, for they admit that in these cases the abdominal lymphatic glands, through which the pigment was supposed to pass, were of 'ivory-like whiteness and free from any obvious impregnation with carbon particles!'

"But in Whitla and Symmers' experiments some of the animals had the Chinese ink, rubbed up with olive oil and water, introduced into their stomachs by means of a soft indiarubber catheter passed through the mouth, pharynx, and esophagus. This must be regarded as a dangerous procedure in experiments in which it was necessary to exclude the possibility of direct admission of the pigment-containing liquid into the air passages, and it is therefore quite possible that

1. Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 301.

aspiration of the liquid was the explanation of the ebony-black lungs found in some of the animals.

"Probably, however, the main source of error in these experiments was that the authors did not attach sufficient importance to the frequency of spontaneous anthracosis in adult guinea-pigs. This suggestion finds striking support in the fact that the authors were unable to find pigmentation of the lungs when they selected young guinea-pigs. 'In ordinary feeding experiments when the carbon was mixed with the food of these young animals we found usually that neither the glands nor the lungs became visibly infiltrated with carbon particles, the intestinal contents alone being black.'"

In summing up, M'Fadyean considers "The older view, viz. that the carbon particles are carried directly into the lung tissue with the inhaled air, has been thoroughly vindicated, and the contention that a degree of pigmentation of the lung tissue and bronchial glands comparable with what is commonly encountered in men and animals can be produced experimentally by feeding with any amount of carbon or Chinese ink must be considered disproved by the weight of experimental evidence.

"In reality, however," M'Fadyean continues, "any discussion of the route by which the soot particles reach the lungs in natural cases of anthracosis has become quite superfluous when one is considering whether primary pulmonary tuberculosis is caused by the inhalation or by the ingestion of tubercle bacilli. It is now absolutely vain to cite the experiments of Vansteenberghe and Grysez, since, as has already been shown, the possibility of producing a direct infection of the lung with tubercle bacilli by inhalation has been absolutely proved."

Sir John M'Fadyean states the following

Conclusions.

"(1) The inhalation of tubercle bacilli suspended in the atmosphere is a very certain method of infection in susceptible animals, even when small doses of bacilli are employed.

"(2) Experimental infection with tubercle bacilli by way of the alimentary canal is comparatively difficult to realise, even in highly susceptible animals, and success is certain only when very large doses of bacilli are administered.

"(3) With few exceptions, in animals experimentally infected with tuberculosis by way of the intestine, the primary lesions are intra-abdominal, and the intra-thoracic lesions when present are secondary.

"(4) Inhalation is probably the commonest natural method of infection in those species (man and cattle) in which the primary lesions of tuberculosis are usually intra-thoracic.

"(5) Naturally contracted cases of tuberculosis in man and other mammals can be ascribed to infection by ingestion only when the lesions revealed at the *post-mortem* examination are confined to the abdomen, or when the existing abdominal lesions are recognisably older than those present elsewhere in the body.

"In formulating these conclusions, I have endeavoured," says M'Fadyean, "to evade the reproach to which Calmette and his supporters have laid themselves open, viz. that of drawing far-reaching inferences from a small number of experiments, and assuming that the results obtained in animals under the conditions realisable in experiments may be immediately applied to explain the method of infection in cases of natural tuberculosis in man. That is why the word 'probably' has been introduced into the fourth of the conclusions. The whole of the experimental evidence on which the theory of the intestinal origin of pulmonary tuberculosis in man was built up has been swept away, and valuable new support has been provided for the older inhalation theory; but one ought to avoid the mistake of denying any importance to infection by ingestion either in man or in cattle, or of asserting that tubercle bacilli which enter the body by way of the alimentary canal are never the cause of tuberculosis with lesions apparently primary in the lungs."

THE SKIN AS A PORTAL OF ENTRY FOR THE TUBERCLE BACILLUS.

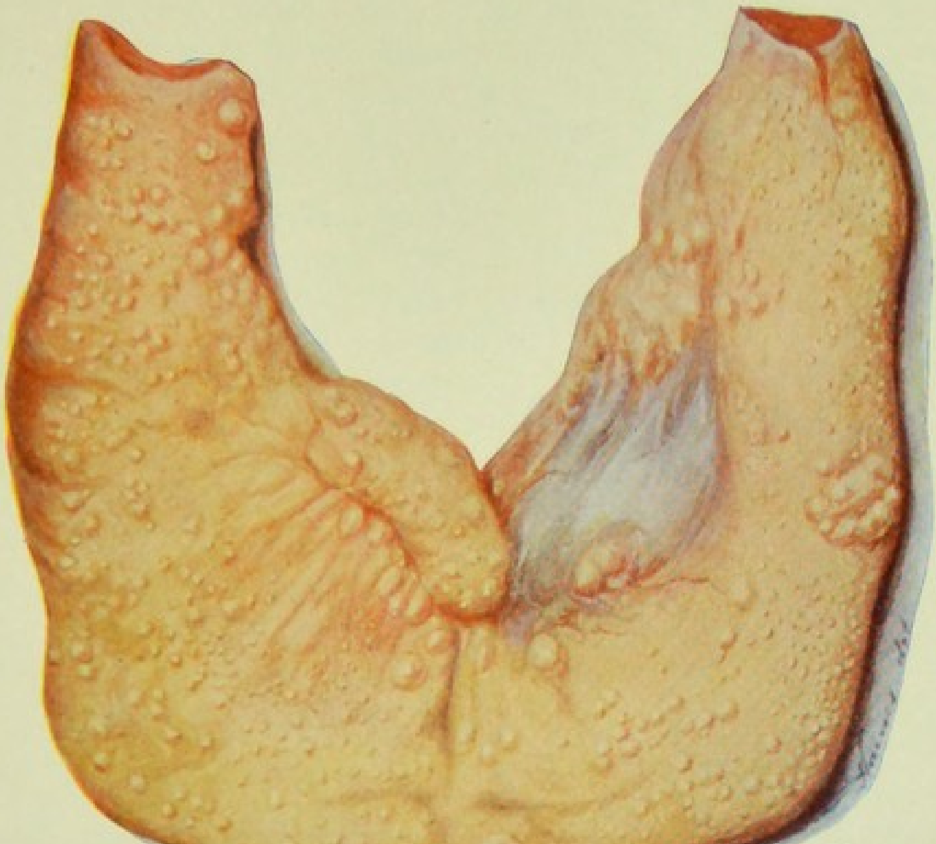
According to Courmont and Lesieur,[1] "The skin itself, although apparently intact, is far from offering an impassable barrier to the passage of the tubercle bacillus (this is probably due to the hair). Hence this portal of entry must not be neglected in medical and veterinary practice. Many tuberculous infections may result from a transcutaneous inoculation (abrasions, epilations, minute lesions, etc.). This principle should be utilised in prophylaxis."

Dr. Isidore Spitzstein,[2] of Budapest, says:—

"Professor Krehl, Heidelberg, discussing the furuncles produced by Garré through percutaneous application of staphylococci and the positive percutaneous infection experiments with guinea-pigs of the Austrian Pest Committee in his Patho-physiology (1906), explains these successful infections through the apparently intact skin by considering it probable that the inunctions produced slight injuries of the surface of the body and of the epithelium of the skin glands. Professor Cornet also emphasises in his book (Die Tuberculose, 1907) that the successful issue of the cutaneous infection experiments (sputum, etc., when rubbed into the skin of the cheeks, nose, etc.) depended entirely upon whether superficial injuries of greater or less extent preceded the infection.

"The experiments of C. Fraenkel (The Activity of Tubercle Bacilli through the Intact Skin, Hygienische Rundschau, 1907) again called our attention to the question, inasmuch as this investigator

1. 6th I. C. on T., Vol. 1, pt. 1, p. 151.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 155.



TUBERCULOUS INTESTINE OF A CHILD.
(Turned inside out.)

produced general tuberculosis in guinea-pigs by treating them through the intact skin."

Although his experiments were unfinished at the time of writing, Spitzstein[1] inclines to the following conclusion :—

" If percutaneous infection is at all possible, it certainly is the most unfavourable mode of infection for the tubercle bacillus ; in the case of the rabbit particularly so, as it is decidedly refractory to the disease."

LOCATION OF LESIONS AS A GUIDE TO PORTAL OF INFECTION.

We are now in a position to appreciate the dictum of Weechselbaum,[2] of Vienna. After summing up the different portals through which tubercle bacilli may enter the body, this investigator points out that the resulting lesions give us no information relative to the point of entrance. He asserts, we are reminded by Schroeder,[3] that the latency of tubercle bacilli and the facts that they may induce a simple hyperplasia[4] or enlargement due to simple cell proliferation, that they may pass through the mucous membranes or lymph glands without causing lesions, that different organs of the body may have different degrees of immunity, etc., must all be taken into consideration in a study regarding the portals of entry, and that deglutition, or the act of swallowing, must be given a greater significance as a means of infection with tubercle bacilli than it has hitherto received.

Jensen[5] points out that ". . . . with swine that are infected almost exclusively through the digestive canal, tuberculosis of the intestines is an exception, while miliary tuberculosis of the lungs often leads to a rapidly developing caseous pneumonia."

Nevertheless, the consideration of the

PREVALENCE OF ABDOMINAL TUBERCULOSIS IN CHILDREN

occupies an important place in tracing the source of human tuberculosis. If it be revealed that in a large number of cases the disease starts in the food tract there is good reason to suspect food as the carrier of the infection.

Thorne on the Registrar-General's returns

According to Professor John M'Fadyean,[6] " The late Sir Richard Thorne Thorne, in the Harben Lectures on the Administrative Control of Tuberculosis, which he delivered in 1898, expressed his conviction that tuberculous milk was the main cause of *tabes mesenterica* in

1. 6th I. C. on T., Vol. 1, pt. 1, p. 156.
2. Rept. of the International Tuberculosis Conference held at Vienna, Sept., 1907 (Review in Hygienisches Zentralblatt, Vol. 4, No. 10, 1908, p. 291).
3. 25th Annual Rept. B. A. I., p. 141.
4. "Hyperplasia"—accumulation or new formation of similar structure as of areolar tissue ; an increase in number of the individual elements of a tissue.
5. Milk Hygiene, p. 77.
6. Trans. B. C. on T., Vol. 1, p. 82.

children, and he characterised the loss of child life from this cause as appalling. The evidence on which this formidable charge was laid against the milch cows was of the following nature. The Registrar-General's returns show that during the last fifty years there has been a marked decline in the death-rate from human phthisis, which is the form that tuberculosis generally takes when the bacilli are inhaled. On the other hand, during the same period, there has been only a slight decline in the death-rate at all ages from that form of tuberculosis which is ascribable to alimentary infection; and among children under one year of age there has been a notable increase in the mortality from that form of the disease. The decline in the death-rate from phthisis is ascribable to the great improvements which have been effected during the last fifty years in the hygiene of human habitations, such as improvements in lighting, drainage, and ventilation. These, naturally, have not interfered with infection through milk, which has, therefore, remained unchecked, and in infants has even increased because, during the last fifty years, cow's milk has entered more largely into the dietary of very young children.

M'Fadyean disagrees

"There are several weak points in this argument. Perhaps the weakest of all is the assumption that the deaths certified under the head of *tabes mesenterica* correspond closely with those which the pathologists would classify as cases of primary alimentary infection. It is scarcely possible to doubt that the term *tabes mesenterica* in the Registrar-General's returns covers a heterogenous collection of cases, of which the majority may not be cases of tuberculosis at all. But even if it is agreed to accept all the cases registered under the head of *tabes mesenterica* as instances of primary alimentary infection, the figures found in the Registrar-General's returns do not support the contention that milk is responsible for all the cases of *tabes*. It is true that they indicate an increase in the death-rate from alimentary tuberculosis among children under twelve months old; but, on the other hand, there appears to have been a considerable decline in the death-rate from the same cause at all ages between one and five years. Now, if tuberculous milk were a frequent cause of tuberculosis, one would not have expected the death-rate from that cause to decline among children between one and five years of age, for there is no reason to suppose that there has been any decline in the use of cow's milk in the feeding of children at that age during the last fifty years. The fact appears to be that the Registrar-General's returns do not afford much trustworthy information with regard to the number of cases of primary alimentary tuberculosis, and are absolutely worthless as an indication of the extent to which human beings are infected by means of milk."

Bovine type in children

Bovaird[1] says ". . . . whatever the interpretation of the localisation of the lesions with relation to the path of infection, there is general

1. 6th I. C. on T., Vol. 2, p. 451.

agreement that if infection takes place from milk it will most probably show itself in tuberculous lesions of the intestines, mesenteric nodes, and possibly peritoneum ; in other words, abdominal tuberculosis. This fact has been amply proved, for all recent investigations of the type of tubercle bacilli to be found in human lesions show that the bovine type is frequently (70 per cent.) found in cases of abdominal or cervical gland tuberculosis in children, and rarely in other cases.

"It is, of course, true that the investigations of cases for types of bacilli have not been numerous enough to be decisive, but the evidence available justifies the statement that when abdominal tuberculosis is common, then bovine infection will be found frequent, and not under other conditions."

Koch[1] considered primary intestinal tuberculosis rare in children, and quoted Baumgarten, Virchow, Orth, Ribbert, Albrect, and many others in support.

Dr. David Bovaird, Junr.,[2] New York, states, however, that during a visit to the Royal Hospital for Sick Children, Edinburgh, in 1904, Dr. John Thompson showed him in a single morning more cases of unquestionable abdominal tuberculosis in children than had come under his own (Bovaird's) observation in ten years' work in the dispensaries and hospitals of New York City. Bovaird concludes[3] that the data from Great Britain is at variance with that of France, Germany, and America.

"B. Fränkel reports," according to Schroeder,[4] "that primary tuberculosis of the upper air passages (regions which are exposed to infection carried in food), especially in children, is of common occurrence, and is often associated with an enlargement of the cervical and neck glands. Among fifteen cases of tuberculosis affecting the cervical glands (a condition undoubtedly due to infected food) he found five cases that were caused by tubercle bacilli of the bovine type."

According to Mohler,[5] "Ravenel has collected the number of cases of human tuberculosis which have been studied with special reference to the type of bacillus causing them, whether human or bovine, and states that of the 306 cases reported, 63 (or, approximately, 20 per cent.) were due to the bovine tubercle bacillus."

"Fibiger and Jensen,[6] who likewise obtained from human lesions typical bovine bacilli virulent for cattle, recall that the Imperial German Health Office examined 39 cases of primary tuberculosis of the human intestines and mesenteric glands, and found that 13 among them were caused by bacilli of the bovine type. Later investigations made by Fibiger and Jensen are summed up as follows.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 746.
2. 6th I. C. on T., Vol. 2, p. 448.
3. 6th I. C. on T., Vol. 2, p. 451.
4. 25th Annual Rept. B. A. I., p. 141.
5. P. H. and M. H. S., Bull. 56, p. 504.
6. Berliner klinische Wochenschrift, Vol. 44, Nos. 4 and 5, pp. 93-6, 134-7, 1907 ; quoted by Schroeder, 25th Annual Rept. B. A. I., p. 135.

"Though bovine types of tubercle bacilli are more commonly isolated from bovine lesions and human types from human lesions, there are cultures that must be considered as transition forms, as they have some of the characteristics of bovine and others of the human type."[1]

Bang[2] says that "....even if most of the cases of human tuberculosis are produced by bacilli showing the characteristics peculiar to the human type, there are not a few cases in which bacilli of the bovine type have been found in human beings. The English Tuberculosis Commission found this to be true in 23·5 per cent. of the cases examined; and even the German Reichsgesundheitsamt found it in 13·5 per cent."

Wollstein[3] describes Gaffky's "....study of the bronchial and mesenteric lymph nodes from a series of 300 autopsies in children, of whom 272 were under five years of age. The glands were examined for tubercle bacilli by the inoculation method, and the isolated bacilli tested as to whether they were of the human or bovine type. The result showed conclusively that the human type of tubercle bacillus was almost invariably present; only in 2 of 59 cases was the bovine type apparently found, and even then the bronchial and not the mesenteric glands contained them. A most interesting part of this work shows that while 36 cases were macroscopically tuberculous at autopsy, 90 others were found to contain tubercle bacilli in the lymph glands on animal inoculation. The bronchial nodes were found infectious for tuberculosis twice as often as the mesenterics in the latent cases, and as often in the developed cases; thus proving that even in childhood the respiratory tract is more frequently the entrance point for the tubercle bacillus than is the digestive tract, and that it is the human and not the bovine type of tubercle bacillus which causes the greatest danger of infection in human beings."

Dr. Theodore Shennan[4] analyses the records of the Royal Edinburgh Hospital for Sick Children for 21 years. The records were made by Sims Woodhead, Alexander Bruce, David Welsh, Theodore Shennan, and Stuart McDonald. Shennan naturally accepts it as granted that "....the operations were skilfully performed, and the important facts duly appreciated and accurately recorded."[5]

These investigators found in 413 fully recorded cases of tuberculosis in children, 86 cases of ulceration of the intestine without pre-existing excavation of the lungs, or 20·8 per cent. of the whole. "Even allowing for a large margin of error," says Shennan, "there

1. Presented at the Joint Session of Sections 1 and 7 of the 6th I. C. on T., 1908. See p. 41 of this book.
2. 6th I. C. on T., Special Vol., p. 216.
3. 6th I. C. on T., Vol. 2, p. 426.
4. 6th I. C. on T., Vol. 2, p. 373.
5. 6th I. C. on T., Vol. 2, p. 367.

is still a sufficient number left to prove that, in this country at least, primary ulceration of the intestine occurs frequently."

Bovaird[1] sums up the figures he collected as follows: "....the number of cases of abdominal tuberculosis is found to be four times greater in Great Ormond Street (London) Hospital for Children than in the United States; in the Edinburgh Children's Hospital it is about eight times, and in the Glasgow Children's Hospital about twelve times, greater.

"If, however, we take the frequency of the two types of tuberculosis in the total number of sick children treated, we see that, on the average abdominal tuberculosis is fifteen times as frequent in Great Britain as in this country (United States), the figures being 3·25 per cent. of the total number treated in Great Britain and 0·22 per cent. in the United States."

Raw blames milk

Dr. Nathan Raw[2] says, "I have never met with a case of abdominal tuberculosis or tuberculous glands which had not been fed on cow's milk, and although over 15,000 children under the age of one year have been fed with sterilised milk, and careful records kept, yet no single instance of tuberculosis of the abdomen or glands has been observed."

Jensen[3] quotes Salmon's[4] figures. "While the English tables show the prevalence of *tabes mesenterica* at about 10 per cent. of all cases of tuberculosis, and at about 30 per cent. of all cases of tuberculosis in children, the corresponding figures are for

"Berlin ..	1898	.. 1·8	per cent. and	2·8 per cent.
Paris ..	1897	.. 1·33	,,	,, 1·65 per cent.
New York..	1899	.. 0·47	,,	,, 2·86 per cent.
Boston ..	1900	.. 1·14	,,	,, 4·35 per cent."

Jensen states "This difference is, no doubt, largely due to different interpretations of the *post-mortem* findings ['and to the different degrees of prevalence of tuberculosis among cattle,' adds the translator, Dr. Leonard Pearson], but a partial explanation may also be found in the fact that most of the milk in England is used in the raw state." Fibiger[5] considers this latter view a possible explanation.

Mohler[6] cites the extreme figures for intestinal tuberculosis in children, calculated on the total number of tuberculous cases examined, as 2 per cent. (Bovaird) and 45·5 per cent. (Heller).

In 1901 Professor John M'Fadyean[7] argued that "....if it were a fact that all the statistics relating to this point were unanimous, it would have to be admitted that primary intestinal tuberculosis is rare in the human subject, and that cases of infection through milk

1. 6th I. C. on T., Vol. 2, p. 450.
2. The Lancet, Mar. 26th, 1910, p. 844.
3. Milk Hygiene, p. 78.
4. Relation of Bovine Tuberculosis to the Public Health, 1901.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 751.
6. B. A. I., Circular 153, p. 29.
7. Trans. B. C. on T., 1901, Vol. 1, p. 81.

are still rarer, though even then it might be advisable to take measures to prevent the few cases. But the statistics are not by any means unanimous, and those that are likely to appeal with most force to the people in this country are not at all in accord with those quoted from Germany. During the last few years the evidence obtainable from the *post-mortem* records of two of the largest hospitals for children in this country have been analysed with great care, in order to see what evidence they afforded as to the relative frequency of the different methods of infection in tuberculosis.....There does not appear to be any ground for supposing that there is a large margin of error in these statistics, as the number of cases dealt with was considerable (547 in the two series), and in both series the *post-mortem* appearances were interpreted in a way to which no exception can be taken. In face of these statistics it is not possible to assent to the statement that cases of primary tuberculosis of the alimentary canal are extremely rare. Precisely the contrary conclusion is the one that must, in the meanwhile, be drawn with regard to the state of affairs in this country, viz. that, at least in children, primary infection by way of the alimentary canal is comparatively common."

Bruno Heymann[1] states that primary intestinal infections are, according to German pathologists, very rare. The English statistics, which make it much commoner, are not reliable, for many cases of enlarged mesenteric glands are not tuberculous, yet are, he claims, counted as such.

Newsholme[2] acknowledges that in the Registrar-General's returns many deaths are returned as *tabes mesenterica* in which there is no tuberculosis, but maintains that this error is less than the understatement of the mortality from tuberculosis in early life.

In summing up the results of their investigations on forms of tuberculosis due to infection by food, the British Royal Commission[3] state "The percentage of these cases of alimentary tuberculosis due to the bovine tubercle bacillus is very large. Taking both classes of cases (cervical gland and abdominal) together, numbering thirty-eight, there are seventeen in which the bovine bacillus alone was found, nineteen in which the human bacillus alone was found, and two in which both were found. Taking the primary abdominal cases alone it is seen that in sixteen out of twenty-nine the bovine bacillus was found ; in fourteen of these it was the sole infective agent present."

FORMS OF TUBERCULOSIS FOUND IN INFANTS AND IN ADULTS.

The opinion is gradually strengthening among pathologists that if Koch made a mistake regarding the source of human infection,

1. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.
2. The Prevention of Tuberculosis, p. 23.
3. Final Report, p. 13.

the discussion and research which have resulted therefrom have, at any rate, relieved the bovine race of much responsibility.

In his lecture at the Tuberculosis Exhibition in London, June 16th, 1909, Dr. Nathan Raw discussed this point as follows :—

" Now, at the outset, I want to make it perfectly clear that the human body is attacked by two distinct forms of tuberculosis, which are caused by entirely different methods, and which have no relation one to the other. By far the most important and commonest form of tuberculosis is called consumption of the lungs. This disease occurs most frequently after the age of 15, and is most common between the ages of 30 and 50. It is caused by infection from one person to the other, and generally occurs in overcrowded, badly-ventilated houses, where the sun's rays rarely penetrate, and where the air becomes so polluted as to be dangerous.

" This disease—consumption—causes something like 40,000 deaths every year in this country alone.....I want to lay special emphasis on the fact that consumption is always caused by infection from a consumptive to a healthy person, and has nothing whatever to do with milk. Therefore, if we were to stamp out tuberculosis amongst cattle to-morrow, and a pure milk supply was provided, we should still have to deal with by far the most important mass of tuberculosis in the form of consumption.

Tuberculosis due to milk

" The other forms of tuberculosis in the human body, such as tuberculosis of the bowels—often called consumption of the bowels—scrofulous glands in the neck, disease of the spine, hip, and other joints, lupus, and that terrible disease called tubercular meningitis are, in my opinion, caused by the germs of bovine tuberculosis conveyed in our milk or meat, and it is our special duty to do our utmost to prevent this enormous and entirely preventable amount of suffering, deformity, and death amongst children."

Consumption and other forms of tuberculosis

Anderson[1] says "....it is very seldom that a patient suffering from any of the latter forms of tuberculosis develops the pulmonary form of *phthisis pulmonalis*. Clinically, they appear to be antagonistic to one another, attacking the body at different periods of life and exhibiting, generally, opposite symptoms. To explain these observations, Nathan Raw advances the theory that while the human body is susceptible of attack by both the human and the bovine type of bacillus, yet these bacilli are antagonistic to one another, and do not attack the body simultaneously ; that the human type of bacillus is conveyed chiefly by infective matter, such as dried sputum, and that its chief path of entry is, during the later periods of life, by the respiratory passages to the lungs, where it sets up *phthisis pulmonalis*. On the other hand, during the early years of life, the bovine bacillus gains an entrance to the human body by the ingestion of tubercular milk, and is the causal micro-organism of all the diseases of infancy and childhood

1. Dr. Anderson's Rept., p. 30.

enumerated above (abdominal tuberculosis with *tabes mesenterica*, tubercular joints, spinal disease, enlarged glands, strumous conditions).

"....the antagonism between the two types of bacilli appears to be corroborated by von Behring and Romer in some of their recent experiments on the immunisation of bovines by human bacilli against bovine tuberculosis. Hence, if human bacilli protect bovines against bovine tuberculosis (see Vaccination, p. 386) is the converse true, *i.e.* does bovine tuberculosis in children protect them against human tuberculosis, or *phthisis pulmonalis* ? The affirmative is the natural deduction. But although the theory is ingenious and attempts to explain away many of the difficulties which at present beset the problem of tuberculosis, we must await the final verdict of scientific evidence."

According to Miller and Woodruff,[1] " The occurrence of pulmonary tuberculosis in children of tubercular parents is much more prevalent than is usually supposed," yet " the type of pulmonary tuberculosis generally seen in adults is extremely rare in children under ten years of age."

Hutchinson[2] says, however, that "....the lung is the most frequent site of tubercular involvement in children, as in adults," and continues that its frequency is much greater than was formerly supposed. Whatever the port of entry, the lung suffers most severely and frequently, and instead of tuberculosis having a special preference for the bones, joints, and glands in childhood, the tuberculous process in these regions and tissues would appear to be secondary to the involvements of the lung, and to represent a residual stage of a generalised infection. Also it would appear probable that even the glandular forms of tuberculosis did not represent an earlier or milder form of the infection, but are secondary to a pulmonary involvement.

Infantile tuberculosis due to direct transmission

Floyd and Bowditch[3] examined the children in homes with a tuberculous patient, and state: " In our study of 1,000 children it appears that whatever the mode of entrance might have been, probably direct transmission of the disease from parent to child was the most important factor. Of these cases 679 have been in immediate contact with tuberculosis in the home, and of this number 36 per cent. showed definite signs of pulmonary consolidation. This type of infection has been strikingly demonstrated in a large number of instances. Following one open case of tuberculosis in a parent, evidence of the disease was found in all but one of the five children. This has been true not only of one but of many families."

In an examination of the figures obtained by the last British Royal Commission for sixty cases of human tuberculosis, Newsholme[4] says :

" It will be noted that fourteen out of the total number of strains

1. 6th I. C. on T., Vol. 2, p. 490.
2. 6th I. C. on T., Vol. 2, p. 421.
3. 6th I. C. on T., Vol. 2, p. 494.
4. The Prevention of Tuberculosis, p. 134.

obtained from human sources conformed to the bovine type. Out of nineteen cases of primary abdominal disease, in which infection might be through ingestion, ten were of bovine type; out of eight cases of tuberculous cervical glands, in which similar infection during swallowing might occur, three were of bovine type; whereas only one strain of the bovine type was obtained from sputum out of four examined, and none from diseased lungs out of ten examined. Of four cases of bronchial gland disease two were of the human type and two doubtful. Of ten cases of joint tuberculosis all were of the human type.

"It would be unjustifiable to infer from the above figures that probably fourteen out of sixty, or about 23 per cent., of all cases of human tuberculosis are derived from tuberculous cattle. If the single sputum case be admitted, the parts affected in the above cases of tuberculosis of bovine type are the mesenteric and cervical glands. But primary tuberculosis of these parts causes less than 10 per cent. of the total mortality officially recorded as due to all forms of tuberculosis in this country. If the twenty-eight cases of cervical and primary abdominal tuberculosis are assumed to be typical of what similar examination on a larger scale would show, it is noteworthy that thirteen of these, *i.e.* about half, were of the bovine type. This would reduce the 10 per cent. above mentioned to 5 per cent., and until further evidence accumulates it may be convenient to assume that from 5 to 10 per cent. of the total human mortality from tuberculosis is due to infection from bovine sources.

Proportion of bovine infection

"This assumption will be subject to modification if future investigations show that the bovine bacillus can be transformed into the bacillus of human type."

"It is perfectly true," says Dr. Martha Wollstein,[1] "that the localisation of the oldest lesion is not always synonymous with the point of entrance of the tubercle bacillus, and that the greater number of cases of extensive pulmonary as compared with intestinal tuberculosis by no means proves that all such cases result from aspiration rather than from ingestion of the bacilli."

Mohler[2] confirms this view, while Newsholme[3] shows that when tuberculosis of the lungs is accompanied by intestinal tuberculosis the latter is the secondary infection.

Obviously, the lung is the principal site of human tuberculosis both in children and adults, but at the present stage of our inquiry we have still to find the main mode of its infection. We approach the crux of our question more closely, however, by examining

THE TYPES OF TUBERCLE BACILLI FOUND IN HUMAN LESIONS. ARE THEY HUMAN OR BOVINE STRAINS?

Ravenel[4] does not ". . . . think it possible, with our present knowledge,

1. 6th I. C. on T., Vol. 2, p. 424.
2. P. H. and M. H. S., Bull. 56, p. 503.
3. The Prevention of Tuberculosis, p. 320.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 685.

and it may be many years before we have sufficient knowledge, to determine the number of cases due to the bovine bacillus as compared to those due to the human bacillus. There can be no doubt," he thinks, "that at the present time the human phthisis is the phthisis that we must look at for the greatest number of victims." He "....cannot agree that the proportion of cases due to the bovine bacillus is insignificant," but emphasises the "....fact that to stamp out this disease both sides must be looked after. There is no use of keeping cats out if you are going to let the kittens get in. The kittens will grow to be cats, and, therefore, it is important to guard against tuberculosis in cattle, not only from the public health standpoint, but because it is a most serious economic question in almost every civilised country."

Theobald Smith[1] says that "A rough and liberal estimate would make from one-fourth to half the cases of tuberculosis, starting in the cervical and the mesenteric lymph nodes, bovine in origin." They point almost exclusively to the digestive tract as the portal of entry, and are largely restricted to childhood.[2]

Duval[3] examined four cultures recovered from peculiar cases of primary cervical adenitis in man, three of which terminated fatally of disseminated acute miliary tuberculosis in from four to six weeks.

One culture proved to be of human origin, one bovine, and the remaining two intermediate forms. It is to be noted that the bovine organism "....manifested a low degree of virulence for rabbits, which is exceptional for bovine cultures."

On the subject of primary cervical adenitis, Lewis[4] sums up the work of the German Imperial Health Office, Smith, British Royal Commission, Oehlecker, and certain other cases. He concludes from the above "....that about one-third of the cases of primary cervical adenitis are due to bacilli of the bovine type." From his own examination of seventeen cases, Lewis[5] concludes that "....the bovine type of infection would seem to be more common in children, the human in young adults, although the limitation is not an absolute one."

Park and Krumwiede, Junr.,[6] determined the type of organism present in 436 cases of human tuberculosis, and tabulated their results. They have also tabulated the results of similar investigations of 606 cases by the following observers :—

Smith ; Smith and Brown ; and Lewis.

Ravenel.

De Schweinitz, Dorset and Schroeder ; and Mohler and Washburn.

Kossel, Weber, and Heuss ; Weber and Taute ; Oehlecker and Dieterlen.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 653.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 652.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 727.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 693.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 696.
6. Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, 1910, p. 137.

Weber.
Hoelzinger.
De Jong-Stuurmann.
Dammann and Müssemaier.
Henschen, Jundell and Svenson.
Rabinowitsch; and Beitzke.
Royal Commission.
Watt.
Kitasato.
Hess.
Gorter.
Fibiger and Jensen.
Burckhardt.

Combining the two, they arrive at the following table, thus giving the results of 1,042 cases :—

Diagnosis.	Adults 16 years and over.		Children 5 to 16 years.		Children Under 5 years.	
	Human.	Bovine.	Human.	Bovine.	Human.	Bovine.
Pulmonary tuberculosis ..	568	1 ?	11	—	12	—
Tuberculous adenitis. Axillary or inguinal ..	2	—	4	—	2	—
Tuberculous adenitis. Cervical	22	1	33	20	15	20
Abdominal tuberculosis ..	15	3	7	7	6	13
Generalised tuberculosis. Alimentary origin ..	6	1	2	3	13	10
Generalised tuberculosis ..	28	—	4	1	28	5
Generalised tuberculosis including meninges. Alimentary origin	—	—	1	—	3	8
Generalised tuberculosis including meninges ..	4	—	7	—	45	1
Tubercular meningitis ..	—	—	2	—	14	2
Tuberculosis of bones and joints	18	1	26	1	21	—
Genito-urinary tuberculosis	11	1	1	—	—	—
Tuberculosis of skin ..	1	—	1	—	1	—
Miscellaneous cases :—						
Tuberculosis of tonsils ..	—	—	—	1	—	—
Tuberculosis of mouth and cervical nodes ..	—	1	—	—	—	—
Tuberculous sinus or abscesses	2	—	—	—	—	—
Sepsis. Latent bacilli ..	—	—	—	—	1	—
Totals	677	9	99	33	161	59

Mixed or double infections, four cases.

The preceding tabulation includes the cases examined by the British Royal Commission up to the time of the Second Interim Report. Hereunder we tabulate the total cases as described in the Final Report (pp. 10-11) :—

	Human.	Bovine.	Mixed.
Pulmonary tuberculosis, primary	14	—	—
Pulmonary tuberculosis, probably primary ..	26	2	—
General tuberculosis..	3	—	—
Tuberculous meningitis	3	—	—
Tuberculosis of bronchial glands	3	—	2
Tuberculosis of cervical glands	6	3	—
Primary abdominal tuberculosis	13	14	2
Tuberculosis of bones and joints..	13	—	1
Tuberculosis of testicle	1	—	—
Tuberculosis of kidney	1	—	—
Tuberculosis of supra-renal capsule	1	—	—
Totals	84	19	5

The ages of the patients comprising the twenty-nine cases of primary abdominal tuberculosis were as follow :—

Human.				Bovine.			Mixed.
1-3 years	3-5 years	7 years	15 years	1-3 years	4-5 years	8 years	—
8	3	1	1	10	3	1	2

Total, 29.

The Commissioners[1] conclude that " Whether one prefers to regard bovine tuberculosis and the cases of tuberculosis in man which are caused by the human type of bacilli as varieties of the same disease, or as independent diseases, there can be no question that human tuberculosis is in part identical with bovine tuberculosis."

" While it is apparently true," says Park,[2] " that adults, and even children, usually escape infection after drinking a few bovine tubercle bacilli, nevertheless, it is now absolutely established that quite a number of children have contracted fatal generalised tuberculosis from such bacilli.....In adults, we have found no bacilli of the bovine type. In children, we have found a considerable percentage of glandular and generalised tuberculosis to be due to characteristic bovine bacilli."

Anderson[3] says " In human tuberculosis the former type (human) is

1. Final Rept., p. 36.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 161.
3. Dr. Anderson's Rept., p. 23.

present in the great majority of cases, and in a certain proportion of human cases the bovine bacillus is now known to be present and setting up bovine tuberculosis in the human subject. The bovine bacillus, on the other hand, is always present in bovine tuberculosis, and appears to be the organism prevalent in animal tuberculosis."

Schroeder[1] concludes that the evidence shows "....that tubercle bacilli of the bovine type, judged from the standard of those investigators who make the sharpest distinction between human and bovine types, occur in a large proportion of the cases of human tuberculosis where the lesions of disease are located in the organs of digestion and associated structures." This investigator makes the striking suggestion that "....tuberculosis of the lung may eventually be proven to be altogether a secondary and not a primary manifestation of the infection of the body with tuberculosis."

Alfred Hess, M.D.,[2] made an examination of the milk supply of New York, and found seven cultures "....to be of the bovine variety without doubt."

Green and Kotz[3] described a case of miliary tuberculosis in a child of four and a half months. The history and circumstances seemed to indicate bovine infection as the source, and the case is interesting in that the time of infection and the period required to develop fully in the child are traceable. These observers essay to show that an acute attack may be transmitted to the human being when "....there is but one cow suffering from tuberculosis in a herd of ten or twelve cattle. Milk from high-bred cattle," they continue, "may be particularly dangerous, and even from dairies which are clean and well cared for an infection may occur, unless such cattle are most constantly watched, inspected, and tested with tuberculin."

Green and Kotz[4] also refer to a case of abdominal tuberculosis described by Uffenheimer,[5] in which "....autopsy revealed findings characteristic of tuberculosis in cattle."

Dr. Nathan Raw,[6] of Liverpool, is firmly of opinion "....that by far the larger proportion of tuberculous glands, abdominal tuberculosis and meningitis are the result of infection during the milk-drinking period of life (0-3 years)," and that "....when tuberculosis is eradicated from dairy cows, it will be a rare event to see a case of surgical tuberculosis in the human subject."

McCaw[7] "....states that the general consensus of opinion is that surgical tuberculosis is generally of the bovine type."

As the result of very extensive investigation, Raw[8] is also of opinion

1. 25th Annual Rept. B. A. I., p. 143.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 523.
3. 6th I. C. on T., Vol. 2, p. 394.
4. 6th I. C. on T., Vol. 2, p. 393.
5. Münch. med. Woch., July 18th, 1905.
6. The Lancet, Mar 26th, 1910, pp. 844-5.
7. Quoted by Floyd and Bowditch, 6th I. C. on T., Vol. 2, p. 496.
8. The Lancet, Mar. 26th, 1910, p. 847.

that "....*all* cases of tuberculous meningitis, together with gross tuberculous deposits in the brain, are due to bovine infection from milk. I have had under my care," continues Raw, "207 cases of tuberculous meningitis, and in every case the child has been fed on cow's milk. I have never seen a case of tuberculous meningitis which had only been fed on its mother's milk; and, what is more remarkable, out of over 4,000 cases of ordinary phthisis, I have never seen one of them develop tuberculous meningitis in the course of the disease."

Lupus

Raw[1] also believes "....that lupus is *always* of bovine origin, and may be conveyed by infection from person to person." He is so specific in his distinction between infections of human and bovine origin that in the case of the lungs he terms a bovine infection as "Bo-phthisis."[2]

Bo-phthisis

"The comparatively greater frequency with which tubercle bacilli of the bovine morphological type are isolated from children, in whom the tuberculous processes are of an acute rather than a chronic character, than from adults," is regarded by Schroeder[3] as a significant fact relative to the source from which the tubercle bacilli that infect persons are derived. Schroeder refers, of course, to milk.

Writing in 1911, Russell and Hastings[4] state that "It has been shown beyond all doubt that tubercle bacilli from cattle are able to cause the disease in human beings. If infected foods, such as meat and milk, are consumed in a raw state there is opportunity for infection. It is not believed that adults acquire tuberculosis easily from the use of such food, but with children the case seems to be far different. From the data collected within the last ten years. it seems probable that about 20 per cent. of tuberculosis in children, *i.e.* those under sixteen years of age, is due to organisms coming from cattle."

Raw[5] points out that several observers have strongly stated that 80 or 90 per cent. of all necropsies show a tuberculous infection, and furthermore state that the great majority of them are not human but "....mild bovine infections which have healed and caused no further trouble, although some of them light up after measles and other acute diseases and cause a general tuberculosis."

As pointed out by Dr. Ernest E. Glynn,[6] Raw's views regarding the bovine source of tuberculosis of glands and joints are not corroborated by the work cited by Lewis (see p. 160). Glynn reminds us that 34 out of 56 cases of cervical gland tubercle were caused by bacilli of the human type; furthermore, that the Royal Commission had found that 16 out of 30 cases of gland tubercle, and 9 out of 9 cases of

1. The Lancet, Mar. 26th, 1910, p. 848.
2. The Lancet, Mar. 26th, 1910, p. 844.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 606.
4. Wis. Agr. Exp. Sta., Cir. of Information, No. 23, p. 10.
5. The Lancet, Mar. 26th, 1910, p. 844.
6. The Lancet, Mar. 26th, 1910, p. 861; also Brit. Med. Jour., April 2nd, 1910, p. 811.

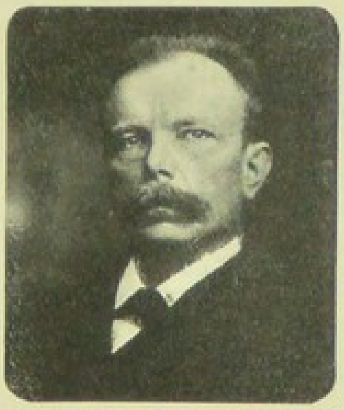
joint tubercle, were also of the human type, "....though Dr. Raw claimed 'that their findings entirely corroborated his views'"—a claim which surprised Dr. Glynn.

Bruno Heymann[1] also rejects Dr. Raw's conclusions. The English and German Commissions, who were specially looking for bovine cases, says Heymann,[2] isolated altogether 271 strains, of which only 39 were bovine. Gaffky, out of 57 consecutive cases in children, found only two which were bovine. Beitzke, in 25 cases of tubercular children, found two bovine. All pulmonary cases are due to the human bacillus.

Heymann also cites the work of Oehlecker, who investigated 50 cases of surgical tuberculosis and found only four to be of bovine origin. These facts are strangely in opposition to the findings of our Liverpool specialist ; but up to the moment of writing no explanation is discoverable.

Jancso and Elfer[3] examined the tubercle bacilli from 93 tuberculous patients, and concluded that none of the strains were of bovine origin.

Tendeloo[4] has pointed out that even when a particular strain is shown to be bovine it still remains to be proved that the infection has been derived from a bovine animal. It is agreed that at some period in its history, or that of its progenitors, it emanated from a bovine, but may have been propagated in the bodies of humans. The question then arises as to which source is to be held responsible. For our part, we fail to see that the bovine is exonerated by having infected a number of human beings instead of one, although it cannot be charged with infection propagated by human beings.



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According to von Behring's theory that human tuberculosis results from bovine infection through milk, one naturally would expect to find the bovine organism in human lesions. The fact that such is not the case may, of course, be explained on the basis that the organism has been transformed into the *typus humanus*.

Newsholme,[5] however, rejects this explanation and adduces evidence against "....the conclusion that transformation of *typus bovinus* into *typus humanus* occurs during the lifetime of a single person."

1. Zeit. f. Hyg., Bd. 60, H. 3.
2. See Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 58.
4. 6th I. C. on T., Vol. 1, pt. 1, p. 86.
5. The Prevention of Tuberculosis, pp. 137-8.

Tendeloo[1] admits that one passage is insufficient, and asks "Why should it alter these characteristics instantly after entering from a human body into another human body?"

DILUTION AS A SAFEGUARD AGAINST TUBERCULOUS MILK.

It seems to be clearly established that a certain number of the bacilli of tuberculosis are necessary to produce infection, so the question naturally arises whether milk in which the organism can be detected in small numbers is a serious source of danger. Milk as usually met with is the product of a number of cows, and if the secretion of one of them happens to contain tubercle bacilli the proportion of these is diminished by the admixture with the milk of the healthy cows. Dr. A. G. Anderson[2] regards this as a "....safeguard against infection," and explains that "....infection through the intestinal tract by ingestion requires larger doses of bacilli to produce the same effect than what is required by inhalation." Many observers have dilated upon the difficulty of infection by ingestion.

Difficulty of infection by ingestion

We have already seen that Delépine (see p. 96), on account of the dilution, rather discounts the danger to be apprehended from contamination of milk with tuberculous fæces.

Degree of effective dilution

Hirschberger[3] found in one of his experiments with tuberculous milk that when diluted 20 times it gave a positive result, but when diluted 40 times the result was negative.

Dr. J. F. Anderson[4] explains, in connection with his experiments, that when two animals were inoculated with the same sample of tuberculous milk, both did not always develop tuberculosis; this would indicate "....that the bacilli are so few in the amount inoculated that one of the animals, by being a little more resistant, was able to overcome the infection."

The work of Alexander (p. 39) and Webb, Williams and Barber (p. 212), among a great deal more we might cite, leaves no doubt that the degree of infectivity of tuberculous milk (or any other suspension of tubercle bacilli) depends upon the number of organisms present as well as upon their virulence. The susceptibility of the host, as we have elsewhere pointed out, also exercises an important influence. Delépine[5] says that "....the number of bacilli has a greater influence on the size of the lesions[6] than on the spread of infection. Time has a greater influence on the spread."

In order to ascertain directly how much milk might be infected by a tuberculous udder, Delépine[7] took some of the milk from an udder

1. 6th I. C. on T., Vol. 1, pt. 1, p. 87.
2. Dr. Anderson's Rept., p. 29.
3. Deut. Arch. f. klin. Med., 44, 1889, p. 400; quoted by John F. Anderson, P. H. and M. H. S., Bull. 56, p. 169.
4. P. H. and M. H. S., Bull. 56, p. 196.
5. 38th Annual Rept. L. G. B., Suppl., p. 348.
6. The British Royal Commission confirm this (Final Report, p. 27).
7. 38th Annual Rept. L. G. B., Suppl., p. 353.

in a state of advanced tuberculous mastitis, diluted it with various quantities of cow's milk free from tubercle bacilli, and inoculated a series of guinea-pigs with the various dilutions. The results showed that one part of the tuberculous secretion was capable of infecting 100,000 parts of sound milk, and the experimenter regretted not having pushed the dilution farther, as the microscopical examination of the tuberculous milk diluted 1,000,000 times indicated that it would probably have infected guinea-pigs.

Friis[1] draws attention to the danger of diluted tuberculous milk. In one case, he found tubercle in the mixed milk of 30 cows, only one of which was suspected of having tuberculosis.

Delépine's lengthy experience points in the same direction. It was seldom that more than one cow with clear tuberculous lesions of the udder was found in one herd of moderate size, and the infectivity of the mixed milk was in all cases proved by inoculation.

Salmon[2] states that "In advanced cases of tuberculosis of the udder, the secretion from the diseased quarter may be virulent even when diluted to the extent of 1 to 1,000,000,000. In incipient tuberculosis of the udder, and sometimes in advanced cases, the number of bacilli is very small, and the virulence of the milk can be destroyed by dilution to a greater degree than 1 to 1,000."

Dilute 1,000 times for incipient udder tuberculosis

It would appear then that the degree of dilution secured by the usual size of herds in this country is insufficient to exclude possible infection. Even when infected milk is still farther diluted, as in factories, the danger still exists, so that Eastwood[3] rejects any reliance whatever upon dilution as a safeguard. "On the contrary," he says, "the mixture of milk containing pathogenic bacteria with wholesome milk makes the whole of the mixture infective. When the swine of Minnesota were fed with a mixture of wholesome skim milk and skim milk containing living tubercle bacilli they became infected with tuberculosis; the dilution of the pathogenic material with innocuous material did not prevent them from acquiring the disease. The disease continued to spread, and, being associated with financial loss, necessitated the passing of a law prohibiting the feeding of swine with factory skim milk containing any living tubercle bacilli, no matter how few in number."

Green and Kotz, as we have seen (p. 163), maintain that the degree of dilution obtaining in small herds is insufficient for safety.

HUMAN TUBERCULOSIS IS PREVALENT WHERE MILK IS NOT USED.

That human tuberculosis is prevalent in countries where cow's milk is either unknown, or rarely used, forms, probably, the greatest difficulty to acceptance of the famous theory of von Behring that

1. Deut. Zeit. f. Tiermed., Bd. 19, 1893, p. 115; quoted by Anderson, P. H. and M. H. S., Bull. 56, p. 170.
2. B. A. I., Bull. 38, p. 46.
3. Dr. Eastwood's Rept. p. 74.

milk is the carrier and immediate source of the disease, and even in the case of the more restricted form of infantile feeding tuberculosis the matter is far from clear. Dr. A. G. Anderson[1] admits that we have important facts for which some other explanation will have to be found.

Human tuberculosis in absence of bovine tuberculosis

We have already noted (p. 29) that the Alaskan Indians, Esquimos, and Aleuts do not use cow's milk, yet tuberculosis prevails among them. In certain parts of England, from various causes, little milk is used, as pointed out by Anderson. In Herefordshire the cattle are practically free from tuberculosis, in Jersey entirely so, yet the disease prevails among human beings as in other parts of the country.

Human tuberculosis is also very prevalent in the following countries, but, as will be seen, cannot be ascribed to the use of cow's milk.

Bruno Heymann[2] quotes the Japanese authority, Kitasato,[3] who states that *Perlsucht* (pearl disease—one of the forms of bovine tuberculosis, see p. 2) was only introduced into Japan thirty years ago. (Children never get milk, yet alimentary tuberculosis is very common.)

In Greenland, Heymann continues, no tuberculous milk is to be found, yet tubercular meningitis is one of the most frequent causes of death in children.

In Asiatic Turkey raw milk is never drunk even by adults, while children are breast-fed for two years. Tuberculosis of all kinds is very rife and very virulent.

In Roumania also children are breast-fed for a very long time, and tuberculosis shows no signs of diminution in regions where there is no milk at all.

Bovine tuberculosis was introduced into the Faroe Islands only a few years ago. Out of 342 cases of human tuberculosis, 262 were traced to infection from human sources, and the disease has prevailed for a long time among the people.

In Egypt milk is so dear that it is a luxury to the rich, yet tuberculosis is again very common, especially amongst the Negroes and Berbers. It is only necessary to see one Berber expectorate, says Heymann, to understand why the disease spreads so well.

In the Gold Coast children are fed either from the breast or on a concoction of palm oil.

Heymann comes to the conclusion that the great prevalence of human tubercle cannot be due to bovine tuberculosis, but must be due to some other cause, and that our endeavours to combat the main source of infection must not be abated by a sense of security based on rigid milk and meat inspection.

1. Dr. Anderson's Rept., p. 28.
2. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.
3. Amer. Med., 1904, 9, p. 13.

DANGER FROM TOXIN IN MILK OF TUBERCULOUS COWS.

Mohler[1] reminds us that "Aside from the danger of tubercle bacilli in milk, some investigators (Le Blanc, Ripper, Jemma, and De Michele)[2] consider the milk of tuberculous cows dangerous on account of the toxin it contains, even when bacilli are not present. Michellazzi has injected such milk into tuberculous animals and obtained a reaction, proof of presence of toxin.

Von Behring[3] considers it probable that "....a great many cases of intestinal catarrh in artificially nourished children are due, not to a parasitic, but to a toxic, infection."

These toxins [4]"....pass unchanged through the intestinal mucous membrane of very young individuals, though not through that of healthy older ones." The mucous membrane "....of new-born individuals possesses no continuous epithelial covering, and the gland tubes of the ferment-producing glands are little, if at all, developed at this time."

It is interesting to note the British Royal Commissioners[5] find that when bovine bacilli are injected into the blood stream of birds "Death is apparently caused by the toxic effect of the bacilli, as dead tubercle bacilli intravenously injected will produce the same effects as living."

Dr. Joh Lunddahl[6] reports that at the Congress of the International Federation of Dairying, Budapest, 1909, "It seemed to be proved by observations on milk from tuberculous cows, at various places, even if the milk does not contain tubercle bacilli or if these are killed, that by reason of its content of toxin, it can affect the organism, especially the young or those possessing an open or latent tuberculous focus. Further observations are needed to determine the extent of this danger."

Having experimentally investigated the question, however, Dr. Bruynoghe[7] concludes that "....nothing authorises us to declare definitely that milk coming from animals affected by bovine tuberculosis is capable, after sufficient sterilisation, of causing any obnoxious action in the person consuming it."

Bruynoghe finds that no toxic action is discoverable when free tuberculin or dead tubercle bacilli are introduced into the digestive tract. He quotes the experiments of Löwenstein, who administered large doses without inducing any characteristic reaction indicating a real resorption. Ostertag and Petri have shown that tuberculous

1. B. A. I., Circular 153, p. 33.
2. Weber also quotes the work of Calmette and Breton, Moussu, and Michelazzi in this connection.—Handbuch der Milchkunde, p. 423.
3. The Suppression of Tuberculosis, p. 37.
4. The Suppression of Tuberculosis, p. 39.
5. Final Report, p. 5.
6. Maanedsskrift for Sundhedsplege, Oct., 1909.
7. Rept. of Second International Congress on Alimentary Hygiene, Vol. 1, sect. 3, p. 162.

guinea-pigs fed with food moistened with tuberculin have not shown any reaction. Bruynoghe confirms this, but admits that Calmette and Breton, also Sato, have arrived at the contrary conclusion.

Bruynoghe shows that the injection of one-tenth of one cubic centimetre of Koch's tuberculin into tubercular guinea-pigs usually kills, while twenty times this amount may be harmlessly eaten with food, and even if the experiment be continued for weeks the animals gain in weight similarly with control animals kept under the same conditions but receiving no tuberculin.

As regards dead tubercle bacilli, Bruynoghe admits that, when ingested, these may reach the lymphatic circulation, although he failed to find them microscopically in the coat of the mesenteric glands of guinea-pigs fed with food moistened with an emulsion of dead tubercle bacilli.

Minute histological examination, he admits, might discover them, however. The dead bacilli are soon resorbed by the organism, not only without harm, but it is not impossible that they constitute a source of immunisation for the organism—an hypothesis which is rendered possible by the results of the experiments of Calmette on the vaccination of bovines.

HOW LONG CAN THE TUBERCLE BACILLUS LIVE IN MILK ?

Considering that the *Bacillus Tuberculosis* is an obligatory parasite, that is, it can only live and multiply in the body of an animal, it is at once apparent that it cannot thrive in milk. If it could be shown that the organism soon dies in milk its presence would have less significance than otherwise. Unfortunately, however, it is otherwise, for although the bacillus cannot thrive in milk, it remains alive for a considerable time, and is ready to thrive and propagate when transferred to a favourable habitat.

Bacilli lose virulence

One may also wonder how long the organism retains its virulence ! For this is the important point. Living bacilli which have lost their virulence are of little account. Vaughan[1] experimented with a strain of tubercle bacilli which was quite innocuous. To prove this he inoculated four rabbits and five guinea-pigs intra-abdominally, and these animals having been killed from three to six months after inoculation, in no instance showed any evidence of infection.

Schroeder[2] refers to the work of Bröers,[3] who showed that tubercle bacilli will live three days in milk even when it has undergone changes that make it unfit for use as food, and twelve days in buttermilk.

1. 6th I. C. on T., Vol. I, pt. I, p. 228.
2. 25th Annual Rept. B. A. I., p. 145.
3. Bröers, C. W., Untersuchungen über die Dauer der Virulenz von Tuberkelbazillen in Milch, Buttermilch, und Butter, Rotterdam, 1905; Review in Zeitschrift für Tuberkulose, Vol. 10, No. 3, p. 260, 1907.

" As milk and buttermilk are rarely used," says Schroeder, " in a raw state after they are more than three days old, it is not necessary to show that the tubercle bacilli which they may contain will remain alive and virulent longer than Bröers has recorded."

Regarding the time that tubercle bacilli may remain alive in milk, Delépine[1] says, " It is generally known that desiccation (drying) or putrefaction do not affect the vitality or virulence of the tubercle bacillus for weeks and months. I have made an experiment which proves that sero-purulent discharge from a tuberculous udder *kept for nineteen months* (part of the time at the ordinary external temperature, but mostly at temperatures varying between 24·8° Fah. and 42·8° Fah.) was still virulent at the end of that period. This milk had been left in the bottle in which it had been originally collected, and it contained other bacteria than the tubercle bacillus. The tubercle bacilli had retained their usual characters and reactions, and their virulence was not very materially diminished. They gave rise to very extensive lesions in inoculated animals."

IS HUMAN TUBERCULOSIS DERIVED FROM BOVINES OR FROM OTHER HUMAN BEINGS ?

Domestic infection

According to Park and Krumwiede, Junr.,[2] " The idea that part of the tuberculous disease in man was to be traced to infection from cattle, had its beginning in the early part of the nineteenth century. Specific attempt at proof was first made by Klenke in 1846, who insisted on the infectiousness of milk from tuberculous cattle. The results of the inoculation experiments culminating in the positive demonstration, by Villemin in 1865, of the infectious nature of tuberculous material from both man and cattle, for other animals, strengthened this view."

Newsholme[3] says that " Tuberculosis is undoubtedly caused most often by domestic infection. Koch[4] says that tuberculosis ' has been frankly and justly called a dwelling disease ' ; while Biermer goes farther and describes it as essentially a bedroom disease. There is little doubt that its infection is chiefly acquired in bedrooms. Industrial conditions, although an important source of infection, probably act to an even greater extent by removing or paralysing influences inhibitory to infection, thus opening the door to infection or stirring into activity infective material latent in the tissues."

[5]" It is....agreed that healthy persons are infected chiefly by inhalation or ingestion of infective dust or by direct infection by minute particles of ejected sputum."

1. Pro. Roy. Soc. Med., Vol. 3, No. 7, Epidemiological Sect., p. 240, May, 1910.
2. Collected Studies from the Research Laboratory, Dept. of Health, City of New York, Vol. 5, 1910, p. 3.
3. The Prevention of Tuberculosis, p. 146.
4. Nobel Lecture on " How the Fight against Tuberculosis now Stands."—The Lancet, Vol. 1, p. 1449.
5. Newsholme, Prevention of Tuberculosis, p. 319.

Social pressure

We have referred to Dr. Nathan Raw's[1] opinion (see p. 142) that ordinary phthisis is contracted by "....inhalation of dried sputum in overcrowded and badly-ventilated dwellings, or by direct contact with consumptive persons in ordinary family life, and especially by kissing."

Sachs[2] believes that "....the familiar type of adult phthisis is probably the result of successive infections."

We may say that even a cursory glance over the literature of the subject will convince the inquirer that if there is one point upon which pathologists, clinicians, and sanitarians are generally agreed, it is that human tuberculosis in the main is conveyed by infection from man to man mostly by the medium of sputum. Koch made no mistake on this point.

Kitasato[3] attributes the spread of the disease in Japan to increased means of development—contact with civilisation. "An evidence of the existence of such conditions," this observer says, "is well disclosed in the extraordinary number of cases of tuberculosis among the girl employees in the cotton mills, weaving and spinning factories..... Frequency of communication, new social conditions which brought about the unequal distribution of wealth, putting a wide gulf between the poor and the rich, and the consequent impoverished nourishment of the poverty-stricken, excessive mental worries and bodily strains undergone from the severe struggle to earn a living—all these conditions contribute towards the immediate cause of tuberculous infection. But Japan is not the first to suffer from these evils of modern times; for the nations of the Occident have likewise had their bitter experiences."

Susceptibility of children

"Cases of tuberculosis in children....which had been very rarely known in times past, have markedly grown in number in recent years. This observation is confirmed by pediatrists."[4]

Bang[5] describes a case of experimental infection of horses with avian tubercle in which the same culture that killed a foal after fifty-five days "....did not leave the slightest deposit of tubercles in two five-year-old horses, one of which was the foal's mother, although they received a much larger dose."

Bang thinks it "....quite probable that a similar condition exists with regard to the susceptibility of human beings to tuberculous cow's milk. It is very likely that the infant is much more easily infected by drinking such milk than the older child and especially than the adult."

Jensen[6] agrees that "It cannot be denied that there is a remarkable difference between the prevalence of feeding tuberculosis of calves

1. 6th I. C. on T., Vol. 1, pt. 2, p. 784.
2. 6th I. C. on T., Vol. 2, p. 485.
3. 6th I. C. on T., Special Vol., pp. 12, 13, 16.
4. "Pediatrist"—specialist in diseases of children.
5. 6th I. C. on T., Special Vol., p. 218.
6. Milk Hygiene, p. 76.

and pigs on the one side, and the prevalence of the unmistakable feeding tuberculosis of man."

Thus Bang[1] describes an experiment in which he "....gave each of five healthy calves, about three and a half months old, 80 c.c.[2] of milk from a tuberculous udder, divided into two portions, given at an interval of six days. When they were slaughtered, after several months to a year, they were highly infected with tuberculosis, and the intestinal and mesenteric glands were evidently the starting point of the disease."

Sachs[3] states that "....the effect of infection in early life on the specific susceptibility of the growing child still remains to be determined by laboratory and experimental research."

Public health experts are generally agreed that tuberculous milk is a highly important factor in infant tuberculosis. Currie[4] believes it "....is the probable cause of the great majority of cases of infantile tubercle."

Anderson[5] considers it probable that "....at least 25 per cent. of all forms of tuberculosis in children in this country is caused through drinking tubercular milk. The disease first shows itself as a primary intestinal tuberculosis, and that in 70 to 80 per cent. of such cases the mesenteric glands become affected, and present the usual clinical appearance as in *tabes mesenterica*."

In discussing the incidence of *tabes mesenterica* among children in Glasgow, Dr. William Watson,[6] on the other hand, points out that the cases are most numerous in the localities where, probably, no milk is used at all.

Delépine[7] believes "....that the milk of cows suffering from tuberculous mastitis is the most important means of transmission of bovine tuberculosis to the infant."

Ordinary tuberculous milk not infective

Ostermann,[8] however, rejects this view. By inoculating guinea-pigs with varying dilutions of milk from cows with udder tuberculosis, he estimated that the worst "single cow" milk he could find had about 10 to 20 bacilli in $\frac{1}{50,000}$ c.cm. One such cow in a herd would cause the milk to contain at least 1,000 bacilli to the cubic centimetre. That this is an extreme case is shown by the fact that only 10 per cent. of the market milks are infectious to guinea-pigs. With 1,000 bacilli to the cubic centimetre in the milk, the butter from the same herd would contain about 100 to the gram. Is such milk dangerous to the human child, he asks, when taken into the alimentary canal?

1. 6th I. C. on T., Special Vol., p. 216.
2. About half a cupful.
3. 6th I. C. on T., Vol. 2, p. 485.
4. Annual Rept. of the Medical Officer of Health, City and County of Chester, 1909, p. 51.
5. Dr. Anderson's Rept., p. 29.
6. See The Scottish Farmer, Nov. 19th, 1910, p. 1034.
7. Pro. Roy. Soc. Med., May, 1909, Epidemiological Sect., p. 218.
8. Zeit. f. Hyg., Bd. 60, H. 3, Review in Brit. Med. Jour., "Epitome of Current Medical Literature," Jan. 9th, 1909, p. 8.

Findél, Reichenbach, and Alexander have determined the minimum fatal alimentary dose for the guinea-pig: 140,000,000 is the minimum for the guinea-pig when taken in one dose; when the dose is repeated 50 times, the minimum is 800,000. Then assuming the consumption of one litre of milk with 1,000 bacilli to the cubic centimetre, we get a daily dose of 1,000,000, which is harmless in a single dose, and only just on the borderland of danger when fed to a very susceptible animal like the guinea-pig. The butter would certainly be harmless. He concludes that the danger from milk is very slight. He does not claim that dairy inspection is unnecessary (he admits its necessity for other reasons), but he claims that we must not expect great improvements from these measures alone. They will do harm if they lead to the neglect of other more important measures. We have already referred to Heymann's arguments on similar lines (see p. 168).

Wladimiroff,[1] on the other hand, considers it "....a dictate of absolute necessity that we should not relax the strict execution of measures already devised against the tuberculosis of cattle, and that we shall exercise minute control over such animal products as milk and butter and meat."

Respecting the relative susceptibility of man, Ziesché,[2] in reviewing the work done with guinea-pigs, is of opinion that it is more than probable that, everything being taken into consideration, we must allow the same number (although it perhaps may be more) inhaled to be able to infect man.

Flügge[3] agrees with this, but Landouzy[4] points out that, according to S. Arloing, "The course, like the manifestation of the disease, depends less on the number than on the virulence of the bacilli, or the connivance or the resistance of the organism, that is to say, the soil." Nevertheless, Bang[5] maintains "....it has....long since been established that the number of bacilli that a person absorbs is of great importance; a few will hardly infect, while a large number surely infect."

Comby[6] maintains "There is no doubt that tuberculous parents transmit tuberculosis to their children, but when they do, it is through contagion. Family contagion explains almost all cases of infantile tuberculosis. Transmission through the milk or flesh of tuberculous cows plays a very insignificant part in the transmission of the disease to the human species."

Tonzig[7] examined the market milk of Padua. Forty-six samples

1. 6th I. C. on T., Special Vol., p. 139.
2. Ziesché, Die Verbreitungsweise und Bekämpfung der Tuberkulose, 1897-8; quoted by Webb, Williams, and Barber, 6th I. C. on T., Vol. 1, pt. 1, p. 198.
3. Quoted by Webb, Williams, and Barber, 6th I. C. on T., Vol. 1, pt. 1, p. 198.
4. 6th I. C. on T., Special Vol., p. 192.
5. 6th I. C. on T., Special Vol., p. 209.
6. 6th I. C. on T., Vol. 2, p. 510.
7. Arch. f. Hyg., 1900, Vol. 41; quoted by Dr. J. F. Anderson, P. H. and M. H. S., Bull. 56, p. 177.

were centrifugalised, and the cream and sediment injected intraperitoneally into 103 guinea-pigs. Nine died within forty-eight hours,[1] and none of the remainder when they were killed showed tuberculosis. Tonzig is of the opinion that the danger of infection with tubercle bacilli in mixed milk is only slight.

Bovine bacillus of secondary importance

"The total number of cases of tuberculosis exclusive of duplicates which were reported in Greater New York in 1907 was, according to Biggs, almost 20,000. Every one realises that this figure is far below the actual number, and yet if we accept it, and if we consider only 1 per cent. of this yearly total to have been of bovine origin, we must attribute 200 of the reported cases to this cause. In view of the studies thus far carried out, both here[2] and abroad, it would seem best, at the present time, to regard the bacillus of the human type as the cause of the great scourge, the scourge of tuberculosis, and to look upon the bovine bacillus as the cause of a definite but much less widespread type of disease."—Hess.[3]

CAN WE ARRIVE AT AN ESTIMATE OF THE DANGER?

Although Dr. Newton Pitt,[4] in a recent issue of the Guy's Hospital Report, has characterised measles and whooping cough as the most important factors in the mortality of early life, tuberculosis is no inconsiderable cause, and is, at any rate, more within our grasp, as we know the causal organism concerned, which, unfortunately, cannot be said for the previously mentioned diseases.

The fact mentioned by Raw that children fed on sterilised milk do not contract tuberculosis of the abdomen or glands (see p. 155) must be accepted as highly significant.

Nevertheless, Kossel[5] believes that "The part played by infection from bovine sources in spreading tuberculosis in man is small in comparison to the danger threatening from a consumptive human being."

Milk secondary to human infection

Newsholme[6] contents himself with the statement that the evidence appears to "....point to the conclusion that, apart from tuberculosis in children," cow's milk "....is a minor vehicle of infection as compared with personal convection by human patients, though very important when considered among the sources of infection external to man."

Bearing in mind Professor John M'Fadyean's[7] discussion of the European figures for primary intestinal tuberculosis in children,

1. Therefore not from tuberculosis.
2. United States.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 528.
4. Quoted by Dr. Edgar P. Copeland, 6th I. C. on T., Vol. 2, p. 379.
5. Quoted by Dr. Wm. Watson, Lecture before the Glasgow and West of Scotland Agricultural Discussion Society. See The Scottish Farmer, Nov. 19th, 1910, p. 1034.
6. 6th I. C. on T., Special Vol., p. 103.
7. Trans. B. C. on T., 1901, Vol. I, p. 84.

particularly the figures for Great Britain (see p. 152), it does not appear that, in the light of our present knowledge, one can see beyond the view advanced by this distinguished pathologist at the memorable Congress on Tuberculosis in 1901. "The danger cannot be defined by stating how many persons are thus affected annually, or what fraction the persons thus infected form of the total number who contract tuberculosis in the course of a year. At the same time, it is impossible to doubt that the danger is a very real one, since at the present time milk is a vehicle by which tubercle bacilli are often introduced into the bodies of human beings."

It would certainly appear, however, that since this discreet pronouncement the evidence against milk seems quite overshadowed by the human sources of infection. Dr. William Watson[1] tells us that Clifford Allbutt[2] allowed his own family and servants, as well as two families living near, to consume the highly bacilliferous milk of a tubercular cow. Not one individual developed the slightest trace of tuberculosis.

"Weber[3] reports that in the period from early in 1905 till April, 1909, 113 instances of udder tuberculosis were reported to the Gesundheitsamte. About 628 persons partook of the milk, mostly over long periods. In forty-four instances it was stated that the milk was boiled or used mixed with that of many cows. In spite of this, and with the close contact with cattle as tuberculous as these, there must have been some transference of the infectious agent. The remaining sixty-nine instances are mainly considered. Milk from these cattle was taken raw or as milk products by 360 persons, 151 being children. In only two instances (ages one and five-sixth years and one and one-fourth years) could definite infections from the milk be determined. They were both cases of cervical adenitis, and the bovine type of bacillus was isolated. Both alive and well two and one half and one and one half years later. The other children in the same families, eight in all, ranging in age from three to twelve years, show no evidences of infection."

Specially interesting from an etiological point is the case reported by Oehlecker (Die Tuberculose-Arbeiten aus dem Kaiserlichen Gesundheitsamte, Heft 6, p. 157), and reported by Weber[4] as follows :—

"A case of cervical gland tuberculosis in a child about one year and nine months old. The child was of good family, both parents and two other children of ages of four to five years proved to be sound. The father was a butcher and had two cows, the mixed milk of which the family used boiled and unboiled. One cow had been in the stable since 1905. She coughed much, and since the end of

1. See The Scottish Farmer, Nov. 19th, 1910, p. 1034.
2. See Encyclopædia Medica, Vol. 12, p. 435. Wm. Green & Son.
3. Quoted by Park and Krumwiede, Junr., Collected Studies from the Research Laboratory, Dept. of Health, City of New York, Vol. 5, 1910, p. 153.
4. Sommerfeld's Handbuch der Milchkunde, p. 421.

August, 1906, was seriously ill. At the beginning of October, 1906, a veterinarian was consulted. He immediately prohibited the further use of her milk. The cow was slaughtered on October 16th and the following conditions found :—

" The lungs, bronchial and mediastinal glands, also one half of the udder, were completely permeated with tuberculosis. The other half of the udder and part of the throat glands were strongly diseased. Further tubercular changes were found in the breast, peritoneum, and liver.

" The third child of the family, born December 6th, 1904, was breast fed until March, 1906, but from January, 1905, had also taken some cow's milk, and since the advent of the tubercular cow, had received boiled and unboiled tubercular milk.

" In August, 1906, the child developed a gland swelling on the left inferior maxilla corner. An abscess formed, and was opened in October, 1906. The bacteriological examination of the matter showed it was an infection with bovine bacilli. The seat of operation and the child appeared sound. The infection does not always take so favourable a course. In a number of cases it has resulted in the death of the children.

" How great is the danger of bovine infection to human beings, how frequently does the reception of tubercle bacilli with milk and milk products bring about the disease? The replies to these questions are not unanimous. The occurrence of tubercle bacilli in milk and milk products, especially in butter, is. . . .a very frequent one. In comparison to it, the infection of tuberculosis in consequence of taking such infected food must be considered a comparatively rare one, as Koch pointed out at the Tuberculosis Congress in London in 1901 and the Tuberculosis Conference in Berlin, 1902. Lately, Flügge tried to approach the solution of the question by having ascertained by Ostermann whether the number of the tubercle bacilli contained in the milk and milk products is generally such a large one that it is sufficient for infection. Ostermann comes to the conclusion that this is not the case; for if one takes even a rare case, that milk is taken with a thousand tubercle bacilli per c.c., in a litre of this milk 1,000,000 tubercle bacilli would be contained—a quantity which, as Flügge assumes by analogy with animal experiments made in his Institute, is surely without effect with repeated doses.

" Butter from such milk would, according to the calculation of Ostermann, contain 100 tubercle bacilli in 1 gramme. In an average daily dose of 50 grammes, therefore, 5,000 tubercle bacilli—a dose which is harmless even with a very frequent repetition.

" As to buttermilk, according to Ostermann, one would have to count on the average a quantity of, at the utmost, 400 c.c. daily, and thereby introduction of not more than 40,000 tubercle bacilli. If one considers that milk is nearly always taken boiled, and thereby the danger considerably decreased, according to Ostermann, no figures remain from which, also with some probability, a widespread infection by milk and butter could be deduced" (see p. 173).

As showing the necessity of determining the type of bacillus causing infections, and in relation to the probable source of infection, we may mention the cases reported by Zwick[1]: "Two supposed cases of milk infection. Both children drank plentifully of milk from a cow with udder tuberculosis. On finding the cow thus badly infected, the tuberculosis in the children was naturally referred to this source, and on their death cultures were isolated and tested with the following results": (Both were found of human type). "Seven other children are healthy."

After reviewing the most important available evidence and expert opinion, Weber,[2] however, arrives at the conclusion that "....precautionary measures should be taken against the danger threatening from the milk of tubercular cows, as, up to the present, no guarantee is offered that trade milk is free from tubercle bacilli, it is urgently advised that milk should be boiled before using. This is only a tentative measure, for the danger from butter containing tubercle bacilli still remains. The danger can only be completely removed when only cows free from tuberculosis are employed in milk production—a desideratum which, owing to the difficulties, at present seems remote."

A writer in the Encyclopædia Medica (vol. 12, p. 435) refers to Pasteur's work on a disease in silkworms. The disease was traced to a micro-organism, but a far more valuable and suggestive outcome of Pasteur's researches was the discovery that so long as the silkworms were in health they laughed and grew fat on the micro-organisms; only when the silkworms deteriorated in condition and suffered from digestive derangement could the microbes enter and cause the disease. This writer offers the opinion, and it would seem we should not err far in accepting it, that "Similarly healthy individuals do not readily acquire tuberculosis, but only such as are predisposed through a general weak condition of body, or through bad environment, or who are the subjects of intestinal or gastric catarrh."

We have quoted the opinion of the Royal Commissioners from their Interim Report (see p. 44). In the Final Report[3] this is confirmed, and the gist of their ten years' masterly investigation brings them to the conclusion that instead of adopting Koch's suggestion to neglect bovine tuberculosis as a source of the human disease, measures should be taken to exclude the recognisably tuberculous cow from the milk supply, whether the seat of the disease is in the udder or elsewhere. The Commissioners are convinced that such measures would result in a diminution of abdominal and cervical gland tuberculosis in children.

1. Quoted by Park and Krumwiede, Junr., Collected Studies from the Research Laboratory, Dept. of Health, City of New York, Vol. 5, 1910, p. 152.
2. Sommerfeld's Handbuch der Milchkunde, p. 423.
3. Page 40.

RESPONSIBILITY REGARDING BOVINE INFECTION AS A CAUSAL AGENCY IN THE HUMAN DISEASE.

"Professor G. Sims Woodhead,[1] Professor of Pathology, Cambridge University, England, a member of the last British Royal Commission on Tuberculosis, stated at the International Congress of 1908, at which he was the British delegate, "I am thoroughly convinced....that until a clear negative is proved, those who take the risk of giving it out that there is no danger to the community, either directly or indirectly, through an increase of tuberculosis among cattle, and that there is no danger of infection from cattle to man, especially to the human infant, incur very great responsibility indeed. As for myself, I am so satisfied with the nature of the evidence that has already been obtained, not only in England, but in Germany, in France, in Denmark, not to speak of important investigations carried on in other countries, that I am unwilling to countenance the relaxation of a single regulation for the control of bovine tuberculosis. Indeed, I will go farther, and state my strong conviction that in the interests of hygiene, and with a view to the final stamping out of tuberculosis from the human race, additional and more stringent regulations will, undoubtedly, have to be drawn up and applied."

Take no risk

Ravenel[2] says "That doubt should have been thrown upon the reality of this danger by the discoverer of the tubercle bacillus has been one of the unfortunate episodes of science. There can be little question that the paper of Koch, read at the British Congress on Tuberculosis in 1901, did an enormous amount of damage, coming, as it did, from so great an authority on this subject."

Ancient ordinances

Salmon[3] reminds us that "There were local laws in Munich more than five hundred years ago which prohibited the use of the flesh of animals affected with bovine tuberculosis, and similar ordinances were subsequently enacted in various German cities."

Crowther[4] relates "As a reporter, I had read Dr. Flick's story of how, in Italy, a hundred years before Dr. Koch proved it in Germany (1782–1882), they had jumped to the conclusion that consumption was infectious, and had enacted laws which made an end of it. They applied the despotic power of the State—they burned the bedding and the buildings, and banished whoever would not fall in with their scheme. Naples, which on account of its climate had been the refuge of consumptives from all over Europe—exactly as Colorado and New Mexico are with us to-day—until the proverb grew up, 'See Naples and die,' a proverb which we have since perverted to mean something quite different, Naples at last, so utterly has the old disgrace been wiped out, became wholesome. Its death-rate from consumption is now much lower than that of New York City.

1. 6th I. C. on T., Vol 4, pt. 2, p. 665.
2. Report of the Second International Congress on Alimentary Hygiene, 1910, Vol. 1, sect. 3, p. 49.
3. B. A. I., Bull. 38, p. 73.
4. 6th I. C. on T., Vol. 3, p. 790.

"These things I read, and I have applied them since to other things than my own case. Can we not do, under our democratic form of government, with all the new knowledge, all our public intelligence upon which we profess to build, what they did in the old, ignorant days under a despotic Government that made no pretence of 'being of or for the people'? If we cannot, then, as a people, we are directly responsible. We have made ourselves responsible before the world. Our democracy will have failed then. It is a fair test.

We can destroy tuberculosis

"Can we battle successfully with the destroyer when it is shown, as it has been, that it is simply a question of understanding plain rules of health and conduct, and of being willing to act them out rather than throw the responsibility and the bill on the Government? We took the government from a ruling class to run it ourselves....If we cannot run it successfully in a matter which so nearly touches the life of our people, then we are not fit. I think we can."

Dyson[1] suggests that "....if a municipality, State, or the Federal Government could be held responsible to the extent of five or ten thousand dollars for the death of every individual caused by the effects of tuberculosis, taxpayers, in order to relieve themselves of an unnecessary economic burden, would not hesitate to quickly and authoritatively direct that prompt and effective steps be taken towards the eradication of tuberculosis in dairy cows and pure-bred cattle herds, with the object of reducing its prevalence in man."

Value of human life

Is it not a serious slur upon us that our experts point out that we can rear our calves and pigs more successfully than our children? Bracken[2] says "The value of human life does not appeal to the legislator as does the value of commercial products."

Letulle and Rey[3] tell us that "In uncultivated rural districts....the peasants usually exhibit an impassive indifference towards any question which does not directly affect their material interests. They pay much less attention to the bringing up of their children than to the rearing of their animals."

Legal protection of hogs against tuberculosis

Eastwood[4] was impressed with the special precautions exercised in America to protect hogs from infection, and wondered why similar steps had not been taken to protect babies. "It is the custom in Minnesota," he says, "for the farmers to send their milk to factories where the cream is removed and the skim milk returned to them for the purpose of feeding their pigs. It was found that the milk frequently contained tubercle bacilli which set up tuberculosis in the pigs and gave rise to a serious economic loss; consequently, a law has been passed requiring the Pasteurisation of all factory skim milk. This law has been in effect for several years, and has given general satisfaction. But the State is unable to pass a law preventing the feeding

1. 6th I. C. on T., Vol. 4, pt. 2, p. 513.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 334.
3. 6th I. C. on T., Special Vol., p. 231.
4. Dr. Eastwood's Rept., p. 54.

of babies with milk containing, or likely to contain, living tubercle bacilli. The reasons why pigs are better protected by the legislature than children appear to be: (1) Pigs have a definite market value, and it is recognised that economic interests must be protected; (2) the need for legislation to protect the health of human beings is less well established; (3) the agricultural interest carries votes at an election; (4) public health interests carry little or no political weight. Pigs in Minnesota are better protected than in some of the other States; but, so far as my experience goes, it is true of all the States which I visited that, for the purpose of effective legislation, economic considerations outweigh considerations of human health. It seems that those who advocate compulsory Pasteurisation of milk intended for human food must acquire more influence than they at present possess before they can carry their point, even if their views be accepted as sound."

Nevertheless, "It is true in fact," continues Eastwood,[1] "that in America the local sanitary authority enforces regulations for the control of the milk supply by the exercise of its own unaided powers, and that the exercise of such powers is sanctioned both by law and by public opinion."

"The eradication of this disease," says Vaughan,[2] "is by no means solely the medical man's problem; it demands the combined intelligence and labour of all men who are interested in the welfare of the race, and the individual who regards it with indifference should find no place in our legislative halls, either national or State. To take the life of a fellow man wilfully or maliciously is murder—the greatest of all crimes; to do so through ignorance or carelessness is manslaughter.....The great majority of deaths from tuberculosis are due to manslaughter, and this fact should be recognised.....The man who sells milk or other food infected with the tubercle bacillus or other disease-producing germs is distributing a more deadly poison than arsenic, and he should be forbidden the continuance of such a practice. We need wise laws in order to restrict and eradicate tuberculosis, and their adoption and enforcement are sure to come as soon as the mass of the people see the matter in the true light. This crusade against tuberculosis is the greatest work that man has so far attempted. We of this generation are starting it, and those who come after us will, we hope, complete it."

PUBLIC HEALTH DEMANDS REGARDING DAIRY PRODUCTS.

Dr. Otto G. Noack,[3] Reading, Philadelphia, reminds us that Damman and Muessemier, at the end of their research work on the relationship of human and bovine tuberculosis, concluded that

1. Dr. Eastwood's Rept, p. 30.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 191.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 987.

Protection against bovine tuberculosis

"Measures for the protection of man against the infection of animal tuberculosis are indispensable."

In reference to human tuberculosis, Ravenel[1] says: "Having demonstrated that there are a certain number of cases due to bovine tubercle bacillus; that a certain number of deaths occur from this bacillus, and having demonstrated that the tubercle bacillus passes into the stomach or gets there from some outside source, it behoves us, from every point of view, to take every precaution possible against contamination of our milk."

Schroeder[2] says "It is imperatively necessary for the protection of public health that all milk should be obtained from cows certainly free from tuberculosis, and from cows stabled, milked, and pastured in an environment free from tuberculous infection, or that it should be Pasteurised or sterilised before it is used as food in any form."

Public awakening

O. E. Dyson, M.D.C.,[3] of Chicago, Illinois, appears to have experienced considerable trouble in the campaign of public health demands as opposed to vested interests. After referring to the booming of cattle of the gold-brick variety, he prognosticates a full awakening of public sentiment to the facts as they exist.

"Then, and only then, can it be expected that the question of economics, in which comparatively few are concerned, will be substituted in favour of a demand for the protection of live-stock interests and public health—the latter unquestionably being a municipal, State, and national liability, and as such should be protected to the extent of utilising modern achievements in the world of hygiene and sanitary science resulting from a knowledge of cause and effect."

This American author refers to the avarice and greed on the part of dairymen and the owners of pure-bred cattle herds, who to-day are resisting with all their might any interference with their present privilege of peddling the contagion of tuberculosis broadcast throughout the land. It would seem that Dyson still regards tuberculous milk as the principal source of human tuberculosis. He asks "What authority can be cited as to the possibility of a child having more resistance to tubercular infection from infected milk than a hog, which every veterinarian knows to be highly susceptible to the infection? Therefore, would it not be well for medical authorities to co-operate with the veterinarians in efforts to remove possibly the principal source of tubercular infection to which the human is to-day exposed, rather than to depend upon sanatoriums and fresh-air funds to cure the disease after infection has taken place, with little or no possibility of such resources ever being able to keep pace with the present unrestricted sources from which the contagion of tuberculosis spreads?"

1. 6th I. C. on T., Vol. 4, pt. 2, p. 685.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 606
3. 6th I. C. on T., Vol. 4, pt. 2, p. 517.

Eastwood[1] quotes the opinion of Dr. Harrington that the powers vested in the English local authorities are inadequate. Contrasting English with American methods, he says, "In this country, happily, these things are better ordered in those States which have adequate health laws. In Massachusetts, for example, the local Board of Health of even the smallest town has power to exclude the milk of an infected or simply dirty dairy, whether that dairy be local or far distant, and without anything more than its own order."

Further powers necessary

The Health Department of the city of Chicago went so far as to object to the feeding of wet malt to milch cows. The legality of the rule was contested, but the Appeal Court upheld the decision of the lower Court on the ground that the disputed clause of the ordinance was "necessary for the preservation of the health of the people and to guard against disease."

"In some cities," Eastwood[2] says, ". . . . the health authorities keep careful records of the number of cases of infectious disease which occur amongst each dealer's customers. If a particular dealer happens to have a heavy score against him an inquiry is instituted which may cause serious interference with that dealer's trade."

Reasonable regulations necessary

Eastwood[3] acknowledges, however, that "Many of the American codes are framed in too aggressive a spirit. The intention is good: they are promulgated simply and solely with a view to advancing the interests of public health, and these interests rightly claim precedence over other and merely commercial considerations. But the requirements of the consumer would be better served if it were made more clear that due regard was also being paid to the actual conditions and difficulties of production. American experience shows that regulations demanding more than the actual producer can reasonably perform are worse than useless: they are always evaded and satisfy nobody; by disappointing the consumer and exciting the hostility of the producer they retard the work of milk reform instead of advancing it."

Eastwood[4] maintains that "*The exclusion from a city of milk which is not provided with a reasonable guarantee that it has been produced under wholesome conditions is justifiable,*" and that "*it would be an advantage to entrust to the local health authorities reasonable and legally defined powers of direct control over the production and sale of milk.*"

The above recommendations were embodied in the Milk Bill set aside in 1909.

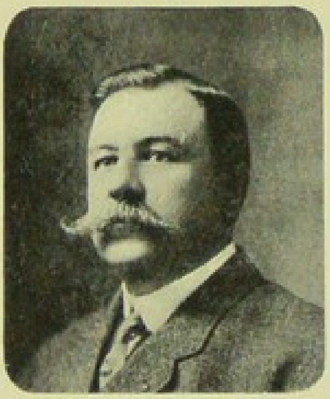
1. Dr. Eastwood's Rept., p. 28.
2. Dr. Eastwood's Rept., p. 50.
3. Dr. Eastwood's Rept., p. 47.
4. Dr. Eastwood's Rept., p. 79.

CHAPTER V.

THE CATTLE OWNER'S STANDPOINT.

LOSSES FROM TUBERCULOSIS IN CATTLE.

BRITTLEBANK[1] estimates the loss owing to bovine tuberculosis to dairy farmers in Great Britain at nearly £1,000,000 sterling annually.



A. D. MELVIN, D.V.S.
Chief of the United States Bureau of Animal Industry, Washington, D.C.

Melvin[2] has applied the very comprehensive figures at his disposal as Chief of the United States Bureau of Animal Industry to the calculation of the losses sustained by this scourge in cattle. Based on the figures of the number of animals found tuberculous in the Federal meat inspection during the fiscal year ending June 30th, 1908, the annual loss in the States is computed as follows :—Cattle, $710,677 ; Hogs, $1,401,723 ; Sheep and goats, $35. Total, $2,112,435. This amounts to two-thirds of the entire loss resulting from condemnations at the time of slaughter in the meat inspection service.

If proper inspection were applied the aggregate estimated loss on all food animals killed in the United States would be $3,832,436 annually, accompanied by a total annual depreciation of the living animals of no less than $8,049,998. Loss of milk, $1,150,000. After allowing for losses in breeding, destruction of cattle in the efforts to eliminate the disease, losses to the trade in live animals and in the animal food products, expense of maintaining sanitary service, disinfection, etc., etc., Melvin concludes that "....the tribute which the United States pays each year to this scourge among its farm animals aggregates more than $14,000,000 (or £2,800,000).[3]

"Such a loss is too great," Melvin continues, "merely as a matter of economics, to be allowed to continue and increase from year to year. And when, in addition, we consider the bearing of animal tuberculosis on human health, it seems imperative

1. The Veterinary Record, June 6th, 1908, p. 874.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 507.
3. Writing a year later, Mohler says : " It has been estimated in the Bureau of Animal Industry that the annual sum that may be charged through loss and depreciation through tuberculosis in cattle and hogs is in the neighbourhood of $23,000,000" (25th Annual Rept. B. A. I., p. 160).

that vigorous measures should be taken to eradicate the disease from our herds, especially when such eradication seems entirely possible and practical."

THE ECONOMIC ASPECT OF TUBERCULOSIS IN CATTLE.

Marshall[1] also considers that "....those interested in dairy cattle cannot afford to allow tuberculosis to run unchecked in a herd," and states that while " The transmissibility of the disease from animals to man is an important question, it is certain that this disease is transmitted from animal to animal."

Reynolds[2] also confirms this view in stating that "Tuberculosis is now recognised as a serious menace to human health, and as an actual source of danger and a constant threat to live-stock financial interests."

Dyson[3] says that " From an economic point of view, tuberculosis constitutes a mortgage of the Shylock variety upon a large percentage of the cattle and hogs now produced in this country (U.S.). Upon that mortgage at least five million dollars must be paid as an annual interest charge."

" The question is," says Deering,[4] " will tuberculosis destroy the cattle industry of the country if allowed to remain in the herds ? The experience of the Maine Commissioners is that it will, and the records that we keep justify us in no other belief. In herds where tuberculosis was allowed to remain, it swept the whole herd, even when every effort (except the right one) was made to separate the diseased animals and to sterilise the milk for the calves at an expense of $5,000 for a plant, under expert medical guidance."

Melvin[5] points out that " The movement in the last few years for a more wholesome food supply has resulted in drawing attention to the part played by tuberculosis as regards both health and economics. It must be realised that the exclusion of tuberculous meat and dairy products from the food supply means a reduction in the quantity of available food, with a corresponding tendency to an increase in the cost of necessaries of life. The economic problem, therefore, concerns not only the stock raiser and the producer, but the consumer, which means practically everybody. No nation is so wealthy that it can afford to sacrifice year after year a considerable and increasing proportion of its food supply, especially when by proper means the loss can be reduced, and in time prevented entirely. This is a problem which must be faced eventually; and the earlier this is understood the more easily it can be solved.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 904.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 944.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 513.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 502.

"Regardless of the question of the communicability of tuberculosis from animals to man, and the bearing of animal tuberculosis on the public health, it is a well-known fact that this disease causes heavy financial loss to the live-stock industry; and while the saving of human life affords the highest motive for combating tuberculosis, the prevention of financial loss is alone a sufficient reason for undertaking the eradication of the disease from our farm animals."

In the struggle against tuberculosis Deering[1] says "We had no success in Maine until the farmers learned that it was for their interest to clean tuberculosis out of their herds."

Mohler[2] agrees that tuberculosis should be stamped out ". . . . aside from any danger to man."

Russell and Hastings[3] inquire: "Why does the farmer so frequently fail to appreciate the danger from tuberculosis? Every farmer," they point out, "is afraid of hog cholera because it quickly causes large losses. It appears, destroys the majority of the herd, and disappears. Tuberculosis causes greater loss, but attracts little attention, because it develops slowly in the animal, and may require years to produce death. The animals decline so slowly that it seems as though some inevitable, unpreventable trouble were present. So human tuberculosis used to be considered. Now, however, it is looked upon as preventable and curable."

WHAT SHOULD WE DO CONCERNING BOVINE TUBERCULOSIS?

Although it is not yet shown that bovine tuberculosis is a great factor in the dissemination of "The great white plague," there are several sound reasons why the matter should receive our deep and earnest consideration. It is not that we do not understand the disease. "It is true," as Pope[4] remarks, "that animal tuberculosis presents peculiar difficulties, but in view of the facts that since 1892 we have had a delicate and certain test for aiding early diagnosis, and that it is within the realm of possibility to destroy all diseased animals at once, the situation is humiliating."

Salmon[5] says "It is even held by Professor Bang that tuberculosis was brought to Denmark in the first half of the nineteenth century by cattle from Switzerland, Schleswig, and England.

Responsibility of Britain

". . . . The British herds appear to be justly chargeable with much of the tuberculosis of cattle and swine which now exists in many parts of the world. The unparalleled skill of the British breeders in developing useful and superior breeds of animals, and particularly of beef cattle, long since attracted the attention of the world, and led

1. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
2. B. A. I., Bull. 153, p. 29.
3. Wis. Agri. Exp. Sta., Bull. of Information, No. 23, p. 12.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 571.
5. B. A. I., Bull. 38, p. 11.

to the diffusion of this improved blood through the herds of many countries. But, unfortunately, the breeders of Great Britain were not as skilful in avoiding tuberculosis as they were in increasing the size, perfecting the form, and hastening the maturity of the animals, and the result has been not only that they unwittingly propagated the disease, but that they distributed it in the most extensive manner.

"It would not be correct to assume, however, as some have been inclined to do, that Great Britain is the source from which has been derived the tuberculous infection of all other lands, for the equal or greater prevalence of the disease in some other countries, notably in Germany, France, Holland, and Belgium, indicates an infection not less remote.

"....Nevertheless, there are many cases in which the introduction of tuberculosis may be clearly traced to British cattle, and among these may be cited the herds of Canada, of the United States, of Argentina, of South Africa, of Australia, and of New Zealand. That the herds of England and Scotland are badly infected there is ample proof."

One hears the American experts warning their stockmen that unless they see to it their herds will soon be as badly infected as the European herds.[1]

The International Commission on the Control of Bovine Tuberculosis[2] state that "Tuberculosis as it exists among the domestic animals of America to-day, undoubtedly owes its primary introduction to the cattle of improved breeding that have been imported from European lands from time to time in the past, for the purpose of improving the native stock of the country."

Mohler and Washburn[3] consider "The effort to control tuberculosis is a most reasonable and proper one, and if conservatively directed should receive the support of every friend of the cattle industry."

Protect the healthy herds

It would seem obvious that the first important step in the campaign would be to protect the healthy herds from infection. There seems to be a difference of opinion as to the number of healthy herds still remaining to us. Delépine[4] doubts that we have many, and yet [5]"In Denmark, where 50 per cent. of the cattle were affected, 22 per cent. of the herds were entirely free from the disease."

One can readily understand that a stock-owner who is doubtful of the soundness of his animals will not court investigation, but those who have faith in the healthfulness of their stock would do well to make certain of the real state of things, and take steps to protect the non-tuberculous animals from infection. In good stocks quite a small proportion would have to be segregated to secure a clean bill of health.

1. See Salmon, B. A. I., Bull. 38, p. 14; also Dyson, p. 351 of this book.
2. Rept. Int. Com. on C. of B. T., p. 22.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 638.
4. 38th Annual Rept. L. G. B., Suppl., p. 402.
5. Salmon, B. A. I., Bull. No. 38, p. 95.

Plan of campaign

Having secured the safety of the healthy herds, we have then to deal with the disease. Shall we endeavour to cure it, stimulate the animals' resisting powers, or attack it ?

It has been maintained that the *Bacillus Tuberculosis* is to be found everywhere (ubiquitous), and, therefore, the only hope of resisting it must depend upon developing immunity in each individual animal. Later and more exact observations have shown, however, that the bacillus is only present in the immediate vicinity of tuberculous animals.

Stop infection

" The indispensable cause of tuberculosis," as Schroeder[1] explains, " is the multiplication of tubercle bacilli in the animal body. Bacilli do not grow and multiply in animal bodies until they have been introduced into them from without, and tubercle bacilli grow and multiply nowhere else in nature. The propagation of tuberculosis, therefore, depends upon the tubercle bacilli that emanate from the bodies of tuberculous individuals, human and animal, and the widespread and common occurrence of tuberculosis is due to the unguarded and dangerous expulsion and dissemination of tubercle bacilli by the victims of tuberculosis. This is the basis for the practically unanimous conclusion among those who are informed on the subject, that in our fight for the suppression and eventual eradication of tuberculosis, we must strive to control and make harmless all the sources from which tubercle bacilli are scattered."

In reference to the human disease, Newsholme[2] reviews the methods which have proved successful in the histories of other infectious diseases, and concludes " We can hold fast to the undoubted fact that the prevention of tuberculosis in the final issue means the prevention of infection.....The correctness of the view that prevention of infection is the main problem is indicated not only (*a*)....by the pathology of the disease, but also (*b*) by the successful extermination of tuberculosis in numerous herds of cattle in one generation by segregation, (*c*) by the analogous experience of other diseases, and (*d*) by actual experience in the diminution of human tuberculosis."

Interception of infection, or breaking the chain, is the method which has availed in reducing the prevalence of the main infectious diseases. This is tantamount to prevention, and authorities are unanimously agreed that it should constitute the fundamental principle by which we should be guided in our fight against tuberculosis.

Prevention is mainly to be secured by separating the infected animals (segregation) and disinfection. Whatever success may be attained with other measures for combating the disease, prevention will probably never, Bang[3] believes, be wholly superfluous.

Delépine[4] concludes that " It is obviously desirable from every point of view to eradicate completely bovine tuberculosis."

1. P. H. and M. H. S., Bull. 56, p. 529.
2. 6th I. C. on T., Special Vol., p. 83.
3. 6th I. C. on T., Special Vol., p. 220.
4. 38th Annual Rept. L. G. B., Suppl., p. 411.

Geo. B. Jobson,[1] Veterinarian, Franklin, Pennsylvania, is not discouraged by the pessimism of the breeders who were quite doubtful concerning the elimination of contagious foot-and-mouth disease and contagious pleuro-pneumonia, which menaced the cattle trade of the United States. [2]" The campaign against the former disease was short, sharp, and decisive ; that against the latter occupied five years, and was finally eradicated with an expenditure by the Federal Government of $1,500,000. The stockmen regarded it as a doubtful and expensive experiment, but the result accomplished in freeing the country from this destructive bovine plague. . . .fully justified the expenditure."

In reporting upon an outbreak of tuberculosis in 1896, in the herd of the Agricultural Experiment Station of Louisiana, Dalrymple[3] made the following statement and recommendation :—

Dalrymple's recommendation

" That as tuberculosis, or consumption, in cattle has been proved to exist in Louisiana, we would urgently recommend that no pure-bred or high-grade cattle should be imported without first having them tested, or obtaining a guarantee that they had been tested at a recent date (prior to purchase) with tuberculin.

" We would further recommend that owners of dairy stock, and especially vendors of milk, should, for their own benefit, both pecuniary and otherwise, and for the sake of the public health, have their cows tested with tuberculin at regular intervals. To be able to satisfy the mind of the public that he was disposing of milk from tested cows only would be the finest advertisement a man in the business could have, and, as a benefactor to his race, in preventing the transmission of this terrible disease to numberless human beings, especially children, he would be deserving, and would be the recipient, of inexpressible thankfulness and gratitude at the hands of the public."

It is quite unnecessary that we should make any more than a passing reference in this connection to the losses from " piners," which nearly all cattle owners are familiar with in this country, nor to the deduction from full market value which the butcher makes by way of insurance against losses met with on slaughter. Trotter[4] states that " Every year there is a distinct falling off in the number of traders who buy home-fed animals for slaughter on account of the risk they incur. They prefer to buy imported meat."

THE LESSONS OF ELIMINATION OF FOOT-AND-MOUTH DISEASE AND CONTAGIOUS PLEURO-PNEUMONIA.

The successful elimination of the above-named diseases from cattle is all the more encouraging in view of the fact that little is known about them even now.[5]

1. 6th I. C. on T., Vol. 4, pt. 2, p. 765.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 765.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 542.
4. The Scottish Farmer, Jan. 28th, 1911, p. 79.
5. See Dyson, 6th I. C. on T., Vol. 4, pt. 2, p. 514.

Insidiousness of tuberculosis

[1]"Pleuro-pneumonia, however, was only dangerous to cattle, whereas in tuberculosis we have to contend with a much more dangerous disease, the consensus of opinion of the best authorities being that tuberculosis may be transmitted to man through the ingestion of bovine bacilli in the flesh or milk of tubercular cattle.....Insidious in its approach, and slowly progressive, it is a far more subtle and treacherous foe, usually giving no visible indications of its presence until it has attained a firm foothold in the herd, and scattered broadcast the germs of infection....."

Counting the cost

Dr. M. H. Reynolds,[2] University of Minnesota Experiment Station, and State Live Stock Sanitary Board, who has counted the cost very well, says that "The problem of tuberculosis eradication is a very different one from the Federal pleuro-pneumonia work of some years ago, which cost only the mere trifle of $1,500,000 and five years time, and involved about six States.

"The eradication of foot-and-mouth disease cost less than $300,000, including about $129,000 indemnity paid to owners of cattle. Those tasks were but as child's play, and relatively trivial in expense, as compared with the work of eradicating tuberculosis from the United States. These two sums combined would be small in comparison with the cost of eradicating tuberculosis from Minnesota or Wisconsin or Pennsylvania, or any one of a large number of States."

Nevertheless, Salmon[3] was of opinion that "There is no reason why tuberculosis should not be eradicated as pleuro-pneumonia was eradicated. The contagion is more widespread, and the expense would be greater, but there are no inherent difficulties to prevent the success of such an undertaking."

Location of Tuberculosis in Cattle.—[4]The Committee on Location of Tuberculosis in Cattle (International Commission on the Control of Bovine Tuberculosis, 1910, see p. 317) stated, "Though we are all agreed that no method for detecting tuberculosis in cattle equals the tuberculin test, we are forced to recognise that the universal application of the test under existing conditions is practically and economically impossible. The number of cattle to be tested, for example, is so great, that if all the available veterinarians and all such other persons as may be trusted to make tuberculin tests should be started on this work at once, and kept at it, years would pass before all the cattle in the United States and Canada could be tested even a single time. Consequently, our efforts to locate tuberculosis among cattle should depend primarily upon other means than the tuberculin test.

"The tuberculin test should be regarded as having only an

1. Jobson, 6th I. C. on T., Vol. 4, pt. 2, p. 765.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 941.
3. B. A. I., Bull. No. 138, p. 93.
4. Rept. Int. Com. on C. of B. T., p. 21.

incidental value in the systematic work of locating tuberculosis, and as being of pre-eminent importance when we undertake the determination of the extent to which the disease is prevalent at any point in any herd where it has been located by other means, or incidentally by the tuberculin test.

"In the order of seeming importance, the means of location may be placed as follow":—

(1) Notification.
(2) Evidence through meat inspection.
(3) The tuberculin test.
(4) Examination of material from cattle and herds (dairy products, centrifuge slime, etc.).
(5) Most important sources of animal tuberculosis.

Under the latter heading attention is directed to those American herds which have been reinforced by European cattle, those which are maintained for sale and distribution; also to herds from which members are exhibited at fairs and exhibitions, and herds which keep males for custom service; herds improved with well-bred stock. Next in order should come all dairy cattle.

PARTICULARLY FINE-LOOKING COWS MAY BE TUBERCULAR.

It is quite noticeable how frequently one meets in the literature of the subject with instances of particularly fine-looking cows being tubercular.

In connection with the observations of Ward and Haring referred to on p. 196, they mention a test made of part of a large dairy herd and not included in their typical figures. [1]"From a herd of 450 cows the foreman selected 50 fresh cows with reference to fine condition and probability of passing the tuberculin test. Those selected represented the choicest animals in the herd. The tuberculin test showed that 41 of them (82 per cent.) were tubercular."

Comparing this figure with the average arrived at by these observers, one is left with the suspicion that the poor-looking cows must have been freer from infection than the handsome ones.

Referring to Schroeder's work on stable infection of guinea-pigs, Mohler and Washburn[2] point out "An interesting feature of one of the stable infection investigations was the fact that the cow which proved to be the most active disseminator of tubercle bacilli was not one that exhibited clinical symptoms of tuberculosis; but, on the contrary, was fat, in excellent condition, and apparently in perfect health. She was the fattest and smoothest appearing individual in a dairy herd of 20 cows, and at the conclusion of the test she was in prime beef condition."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 566.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 631.

PROBABILITY OF DISEASE CONDITION ACCORDING TO AGE.

The very comprehensive figures compiled by Ostertag[1] show that the proportion of infected individuals increases with age at a rapidly increasing rate until at ten to fifteen years probably 75 per cent. of ordinary cattle are visibly tuberculous on slaughter.

Delépine[2] analyses the figures he obtained in Aberdeen in tuberculin testing. His chart shows the incidence of tuberculosis in cattle of various ages and very clearly how the proportion of tuberculous animals increases with age.

Brittlebank[3] states that in the districts surrounding Manchester, where tuberculosis is most prevalent the proportion of old cows is great.

Calves The figures given by Bang for Denmark (see p. 294) are highly instructive. Commenting on the figures, Salmon points out that "....in a country where from 45 to 48 per cent. of the adult cattle are tuberculous, 12·1 per cent. of the calves are affected by the time they are six months old."

1. Handbook of Meat Inspection, 9th Ed., p. 607.
2. 38th Annual Rept. L. G. B., Suppl., p. 408.
3. 38th Annual Rept. L. G. B., Suppl., p. 392.

CHAPTER VI.

SUPPRESSION OF BOVINE TUBERCULOSIS.

FRESH AIR AS A PREVENTIVE.

Experience in Montana

M. E. KNOWLES, D.V.S.,[1] State Veterinarian, Helena, Montana, says " During the past sixteen years, constantly seeing thousands of range cattle, under all conditions, winter and summer, although constantly looking for it, I have been unable to find one single animal showing, under strict range conditions, clinical evidence of tuberculosis, and the Federal Abattoir reports show an infinitesimal number of range cattle with lesions on autopsy.

" Cattle in Montana are ' run ' under three systems : Absolute, or strict open range; partial range and partial pasture, with shed feeding during winter ; and close domestication, where the cattle are always under fence and shed or stable.

" Under both of the last named we find occasional centres of infection, with usually a small percentage of affected animals, the number affected being dependent upon local conditions, usually under semi-range conditions ; the cattle being fed during the winter months in corrals, with sheds for shelter, where there is abundance of shed room, with protection on three sides only. Under this arrangement the number of affected animals in a herd (ordinarily consisting of from 300 to 1,000 cattle) will be relatively small—5 or 6 per cent. ; but where the shelter provided is enclosed on all sides, although the cattle are fed in an open lot or corral, only using the sheds during the night and in stormy weather, the percentage of infection is usually large, in fact, nearly as great as though under close domestication and indifferent sanitation."

It is important to note in this connection, however, that the ordinary cattle shed in the country referred to, as Knowles tells us, is cleaned but once a year, and that " When such sheds are closely packed with cattle at night, or during stormy weather, the atmosphere within them is vile, thick and moist, and in the coldest weather the cattle will be covered with moisture condensed from vitiated respiration.

" Thus do a large number of infections occur among so-called range cattle ; but how different are these conditions from those of strictly range animals, where, from the time they are turned out on the open range until they are rounded up for shipment to the shambles, they never see the inside of a building and rarely even a structure of any sort other than Nature provides.

1. 6th I. C. on T., Vol. 4, pt. 2, pp. 557-8.

No tuberculosis under strict range conditions

"My observation justifies the assertion that tuberculosis of cattle cannot exist under open range conditions, strictly speaking, especially in a high dry altitude, such as we have in Montana, where sunshine, the greatest of bacteria destroyers, is more abundant than it is in Egypt.

"It is possible at low altitudes, subject to greater precipitation, profuse vegetation, and shade-providing foliage, that tuberculosis, being introduced, might persist and perpetuate itself. But even under these conditions range sanitation Nature provides is so salubrious, and conditions are so different from those of semi- or close domestication, so unpromising of filthy conditions, that the disease could not possibly make serious progress.

"During the two years, 1903-04, that Montana's Meat and Milk Inspection Law was enforced, the dairy cattle of each county were tuberculin tested. Four of these have during years past drawn heavily on eastern States for dairy cattle, all the others obtaining their dairy herds from range cattle. Not a single cow reacted in these counties, while those with eastern dairy cattle constituting the majority of the herds, or having been the foundation of them, gave from 18 to 30 per cent. of reactions.

"What better proof could be offered of the freedom of range cattle from tuberculosis? And what better supportive evidence of the wisdom of the modern treatment of tuberculosis in man could be adduced than the evident freedom from this disease of animals living under perfectly natural conditions?"

During a period of about four years (1905-09), Dr. Rutherford[1] made careful observations on a herd of pure bred and grade Ayrshire, Holstein, Guernsey, Hereford, and Shorthorn cattle, originally numbering forty-three animals. Owing to natural increase and the introduction of fresh cattle the number at one time had increased to seventy-five head. The animals were kept under open-air conditions during the whole period, their only shelter being a frame shed one board thick, wind and weather proof above and on three sides, and on the fourth open to a large yard where they were fed in winter, but from which they were at liberty to wander at will. Except when undergoing the tuberculin test, they watered themselves at running streams, on one of which a drinking-place was always kept open in winter. The pasture, which consisted of some two hundred acres of rough land, abounded in natural shelter, the shed itself being situated in a grove of evergreen trees which afforded considerable protection from the keen winds of winter.

All clinical cases had been removed from the herd before the experiment was started, and of the forty-three animals twenty-eight were reactors.

The objects of the experiment were—

1. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 169.

(1) To ascertain the effects of the open-air treatment on the diseased cattle themselves.

(2) To ascertain to what extent healthy cattle kept in contact with diseased cattle were subject to infection.

(3) To ascertain what percentage of healthy calves it is possible to rear without any precautions from diseased cows kept under open-air conditions.

It is admitted that the introduction of fresh animals and the disposition of others of the original herd materially detracts from the scientific value of the results.

Dr. Rutherford concludes: "The evidence, on the whole, leads to the conclusion that open-air treatment is not likely to exercise any marked curative influence on animals already tuberculous, especially when re-infection is possible through cohabitation with clinical cases.

"In view of all the circumstances, the evidence derived from this experiment, as to the likelihood of animals becoming infected under open-air conditions, is of no great value.

"A careful scrutiny of the individual records of the calves reared on the station will reveal a very few cases which might indicate that infection possibly took place after weaning. Most of the calves, however, which became diseased reacted at such an age as to indicate that they derived the infection direct from their dams.

"The proportion of healthy calves raised from the whole herd, namely, 60 per cent., is at first sight somewhat discouraging, but when it is remembered that, with one exception (No. 31), all the cows on which they were reared were affected with tuberculosis, that one had a tuberculous udder, and that a number of the others were open and clinical cases, the matter assumes a somewhat different aspect. It is, I think, highly improbable that such a large percentage of healthy calves could have been obtained from a herd of the same kind under ordinary stable conditions."

In another part of his report Dr. Rutherford[1] sums up the results of the experiments as follows:—

"The data obtained indicate that open-air life is highly beneficial to tuberculous cattle, and that the danger of transmission to adult cattle kept in contact under these conditions is relatively slight. On the other hand, the percentage of healthy calves raised by the diseased cows is, as was to be expected, comparatively small."

Infections under open-air treatment

Dr. Butler[2] describes an experiment in which one reacting cow was placed in a herd of 33 non-reacting dry cows and young beef cattle from two to three years old.

Subsequent testing of the herd showed that 13 of the animals had become infected. The lesions were found on autopsy, and one

1. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 7.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 879.

animal was condemned as being unfit for human food. The cattle were kept in the open air and well fed during the whole experiment.

Dr. C. C. Hayden[1] gave an account of a similar experience with some animals in which he found that the disease was transmitted in the open air just the same as indoors.

Dr. White,[2] in tracing the causes of the dissemination of tuberculosis in Ohio, ascribes it partly to the "....fallacy of fresh-air treatment."

Ward and Haring[3] describe their observations in California, the climate of which is held in high popular esteem as a resort for human tubercular patients.

In Central California cows are only stabled during the time of milking—say four hours a day, and then in structures built so cheaply that the problem of ventilation needs no consideration.

During several months of the year the cows, when dry, live out of doors continuously, feeding on broad ranges of pasture land.

It is to be noted, however, that these herds are built up and maintained by the purchase of cows rather than by the raising of heifers.

The authors summarised certain of their tests, including only figures for whole herds, of five cows or over, which, to the best of their knowledge, had never been tested before. Bulls are included, but no calves.

Among 1,022 cattle tested 326 were condemned, equal to 31·9 per cent. Percentage of herds infected, 82.

The authors point out that this state of things is no better than the results found in the typical eastern State of New York, where cattle are subjected to much closer confinement, and they conclude that the hours of confinement in the stable and climatic conditions—the two great points of difference—exert no influence on the prevalence of tuberculosis in the two States mentioned.

Importance of Infection

" In connection with the control of tuberculosis in cattle, we must not rely," say these observers, " upon regular exercise, fresh air, and stable ventilation as factors in the repression of the disease. It should be recognised that with these sanitary measures, tuberculosis will flourish if we neglect to take into account the tubercular cow and her milk."

Geo. S. Baker,[4] of San Francisco, confirms Ward and Haring with reference to Californian range cattle. He states " The impression is very widespread that an active outdoor life will not only prevent but cure tuberculosis, both in the human and in the bovine. This is

1. 6th I. C. on T., Vol. 4, pt. 2, p. 879.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 879.
3. Archibald A. Ward, B.S.A., D.V.M., formerly Assistant Professor of Bacteriology and Director of the State Hygienic Laboratory, and Clarence M. Haring, D.V.M., Assistant Professor of Veterinary Science, University of California, Berkeley, California. (6th I. C. on T., Vol. 4, pt. 2, p. 564.)
4. 6th I. C. on T., Vol. 4, pt. 2, p. 561.

true only so far as there is freedom from infection. The amount of tuberculosis in range cattle reaching the abattoirs at this point proves conclusively that outdoor life alone is not sufficient to either prevent or bring about a cure.

"My attention was first directed to this in 1900, when, in conducting *post-mortem* examinations of a bunch of steers, I found 0·9 of 1 per cent. showing tubercular lesions. Careful records were kept of this range—hereafter known as Range 1—till April 18th, 1906, when, unfortunately, they were destroyed by the fire; but these records showed a constant increase in tuberculosis until, at the end of 1905, we were getting over 9 per cent. tubercular."

After quoting similar figures for other ranges in the same State, and for ranges in neighbouring States, Baker says: "It is safe to say that practically none of these cattle ever saw the inside of a barn, for while the practice prevails in this State, to a considerable extent, of annually restocking the ranges with dairy calves, very few of these calves are dropped in stables, but live out of doors from the beginning. This is, however, by no means the only source of supply; thoroughbred bulls are frequently introduced from breeding farms. These bulls, if kept till eight years of age or longer, are almost invariably consigned to the rendering tank, on account of generalised tuberculosis, when slaughtered. This condition of bulls is not confined to Range 1; it is true of nearly all the aged bulls killed, and especially so of thoroughbred animals, grades (ordinary cattle) being more frequently free from disease."

Infection the main factor

Mohler and Washburn[1] say "The danger from tuberculosis is not confined to the dairy and farming regions of the country. It menaces the cattle on the ranges of the great plains and the Rocky Mountain regions as well. Heretofore it has been generally believed that the ravages of this disease were confined to cattle that pass at least a portion of the year in stables. This conclusion is now disproved by the spread of tuberculosis in Argentina, Australia, and New Zealand, where the cattle pass their entire lives in the open air, and where the climate is favourable to the cure of tuberculosis in man, as is particularly the case in parts of Australia. The disease seems to have been mainly conveyed to these ranges by pure-bred cattle that have been turned with the native cattle of the various regions for the purpose of improving the quality of the stock."

Concerning outbreaks of tuberculosis, the Iowa authorities[2] say "Some of the worst outbreaks we have investigated were confined to animals that had never been kept in barns."

Russell and Hastings[3] state that tuberculosis may "....spread rapidly amongst cattle that are kept continually out of doors. No

1. 6th I. C. on T., Vol. 4, pt. 2, p. 634.
2. Iowa Exp. Sta., Bull. No. 29.
3. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 8.

conditions, however sanitary, will save a herd constantly exposed to infection from animals giving off tubercle bacilli."

W. H. Dalrymple, M.R.C.V.S.,[1] Louisiana State University and Experiment Station, states "....the genial climate of the Southern States, permitting an almost continuous outdoor existence throughout the entire year, should afford ideal conditions for the maximum of healthfulness in our cattle, and to a considerable extent this is, no doubt, the case. But of itself it is not sufficient, of course, to prevent, although it evidently tends to curtail, the spread of infection when once it is introduced."

Again, [2]"....the outdoor life itself must of necessity be a most important factor in aiding physical resistance on the part of the animal economy."

Dalrymple also tells us that the late assistant veterinarian of the Louisiana Experiment Station, Dr. H. J. Milks, distributed to veterinarians throughout the Southern States a list of questions regarding the prevalence of bovine tuberculosis. Two of the questions were as follow :—

(1) Is tuberculosis prevalent in your State ?

(2) Does the percentage seem larger where cows are stabled than where they are allowed to run at large ?

Dalrymple gives the gist of the replies in his three following conclusions :—

(1) That bovine tuberculosis is prevalent and apparently on the increase in the Southern States.

(2) That this prevalence and increase are almost wholly among stabled or, inferentially, dairy cattle.

(3) That the native, or unstabled, cattle chiefly are practically free from infection, which is probably largely due to their open-air existence and lesser exposure to infection, and, possibly, to their greater natural resistance.[3]

Salmon[4] says " Life in the open air is not always sufficient to prevent infection with tuberculosis or to cure animals that are already affected by it, but its influence is favourable and reduces the chances of infection to the smallest proportion, while at the same time it places the diseased animal under the best conditions for its recovery. In most stables the conditions of life are radically different from what they are in the open air. It is only necessary to make the most casual inspection of the ordinary stable to assure oneself that the conditions of life there are unfavourable in the extreme."

Prevalence of bovine in relation to human tuberculosis

Ravenel,[5] writing in 1898, says: " In Northern Norway, Sweden, Lapland, and Finland, where reindeer contribute the bulk of farm

1. 6th I. C. on T., Vol. 4, pt. 2, p. 533.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 536.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 541.
4. B. A. I., Bull. 38, p. 39.
5. Quoted by Eager, P. H. and M. H. S., Bull. 56, p. 245.

animals, or about Hudson Bay and the islands of the Pacific, where there are only a few cattle, tuberculosis is far less prevalent in man. In Algiers the cattle are few, and live for the most part in the open air and away from cities, and it is found that tuberculosis does not increase among the natives. In Italy, on the other hand, where cattle are housed, Perroncito states that tuberculosis has become the scourge of man and beast."

In this connection one may quote that human beings can contract tuberculosis without infection from cattle, as we find in Ireland at present. (See also Heymann's observations, p. 168.)

The thesis that fresh air is insufficient as a preventive against tuberculosis where there is infection is well shown among human beings in the instances of Indians and Negroes. "To begin with," as Fishberg[1] tells us, "the extreme type of country dweller, those who live always in the open air—as the nomadic Kirghiz Tartars in the Siberian plains, or the aboriginal inhabitants of Australasia, Polynesia, or North and South America—we find that tuberculosis was quite unknown among them before the advent of the white man, who brought to these tribes, not only civilisation, often in the shape of whisky, but also the tubercle bacillus. Never having met with these bacilli, these tribes were very vulnerable, like virgin soil."

We have already noted Fishberg's remark (p. 50) that tuberculosis is essentially a disease of people who live indoors."

"In Nature's health resort," says Lydia Holman,[2] "the mountains, with fresh, pure air, sun, good water, altitude, everything Nature can provide, it seems unreasonable even to suspect tuberculosis; yet at all times can be found some cases in every small settlement, and all over the mountains in the little cabins scattered here and there. Mortality runs high in such isolated districts."

Dr. Bryce,[3] who has control of the Canadian Indians, tells us that these tribes have shown a death-rate of 50 per thousand from tuberculosis. "The danger from meat and milk is eliminated, since the cattle of that region are not infected with tuberculosis and Indians do not use milk. The Indian is in his cottage from October until May, therefore everything is eliminated except the box in which he lives."

Concerning the Negroes of the South, Dr. Sansom[4] stated "Within a few years after the war tuberculosis developed suddenly and became most virulent, because of the huddling together of the Negroes in ill-ventilated dwellings." He concluded that the chief duty of the State should be to aid in destroying these channels of infection.

1. 6th I. C. on T., Vol. 3, p. 424.
2. 6th I. C. on T., Vol. 3, p. 515.
3. 6th I. C. on T., Vol. 4, pt. 1, p. 110.
4. 6th I. C. on T., Vol. 4, pt. 1, p. 111.

Dr. Menville[1] explained that before the war it was in the interest of the owner to keep his slaves in good health, therefore, a physician made bi-weekly visits. To-day there is no such provision. The Negroes live in overcrowded conditions, spend their money in gambling, eat poor food, and clothe themselves poorly.

Dr. Heiser,[2] in closing this discussion, believed that three facts stand out prominently: (1) That tuberculosis is a house disease, a disease of civilisation; therefore, (2) uniform legislation preventing overcrowding must be instituted, and (3) an educational campaign must be begun.

Newsholme[3] sums the matter up in a word when he says "Anything favouring an open-air life diminishes tuberculosis."

Fresh air maintains animal resistance

This author[4] quotes a valuable experiment by Tredeau showing the value of fresh air in maintaining animal resistance to disease. "Tredeau inoculated a number of rabbits with equal doses of tubercle bacilli; half of these were allowed to run free in the open air, and the remainder were placed in a damp hole to which sunlight had no access. Both sets of rabbits were killed at the same time, and it was found that the first had recovered or only had slight lesions, while the second had extensive tuberculosis."

Returning to our bovines, we find Delépine[5] records that "The keeping of cows in the open all the summer and whenever the weather permits is certainly not sufficient to prevent the occurrence of tuberculosis, for I have clear statements regarding ten farms where the practice was adopted, and in seven of these farms tuberculosis of the udder was observed."

No matter how many instances are cited in which animals have contracted tuberculosis despite their open-air life, the physiologist cannot relax one iota his insistence on a fundamental principle—probably the most important principle—for the maintenance of animal resistance to disease. Fresh air stands pre-eminent in this respect. "Not only does it improve the vigour of the animals," says Salmon,[6] "and enable them better to resist infection, but there are fewer chances of infection at pasture or in open pens than there are in stables." Turning to our own country, one finds the Jersey cattle, which live entirely in the open air, free from tuberculosis. Hereford[7] and Irish cattle live largely an open-air life, and are nearly free from the disease.

In the case of the Jersey cattle, however, Bang attributes the

1. 6th I. C. on T., Vol. 4, pt. 1, p. 112.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 112.
3. The Prevention of Tuberculosis, p. 194.
4. Newsholme, The Prevention of Tuberculosis, p. 192.
5. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 232.
6. B. A. I., Bull. 38, p. 80.
7. Dr. Rutherford, Ottawa, Canada, acknowledges, with reference to our Hereford cattle, that "....it is a rare thing to find a case of that disease." —6th I. C. on T., Vol. 4, pt. 2, p. 877.

absence of the disease to the fact that importation of foreign cattle is prohibited except for immediate slaughter. (See p. 300.)

Practicability of fresh-air treatment

The question immediately arises whether cows would suffer if exposed to the general inclemency of winter in Britain. In this connection the experiments made at the Harper Adams Agricultural College[1] during the years 1901-04, on keeping cows out during the autumn, are interesting and instructive. The report published in 1904 states that "The regular practice in Shropshire is to bring all milking cows into the house at night about the end of October, a proceeding which, of necessity, entails extra labour in attendance, and also feeding in the shape of extra hay in the racks and extra straw for bedding at night."

Two lots of five cows each were selected, so as to be as nearly equal as possible in all respects. One lot was brought under cover in the autumn, while the other lot was kept out until December. Records during and previous to the experiment were kept of the yield and quality of milk, and the live weights of the animals.

The report concludes: "The results for the four years are decidedly in favour of leaving animals out at pasture during the night, and from the fact that there is a greater increase in live weight where the animals are turned out, it is apparent that they do not suffer by the treatment. Observations were made on the animals on very cold nights, and they were found lying down close to the homestead. No shelters were available for the animals, and they did not appear to seek shelter from the hedges."

The extra cost of keeping cows in at night is estimated at 1s. 3d. per head per week, not counting attendance and leaving out of account that the animals turned out would probably consume more grass on the pasture.

Mr. Aubrey W. Mann, Leigh, Worcester, wrote us under date of April 27th, 1908, concerning his ". . . . cows which have been turned out the whole winter day and night in sheltered orchards, which system I have adopted for the last three years, and have been more satisfied with the health and condition of the animals than when they were kept in, not having one 'sick or sorry.'" In a letter dated July 27th, 1911, Mr. Mann informs us that he still adheres to the practice with continued satisfaction.

Mr. H. Standfield,[2] Barford Farm, Wimborne, says: "My cows have been lying out all the winter with the exception of two nights, and your last analysis showed the quality of the milk did not suffer, but I fear the quantity has diminished." Sixteen months later Mr. Standfield[3] writes that he still adheres to the practice. "The cows," he says, "have continued to be quite healthy all through, but perhaps

1. Harper Adams Agricultural College, Newport, Salop (Bull. No. 4); also Report for Season 1909, p. 29.
2. Letter dated March 4th, 1910.
3. Letter dated July 28th, 1911.

we did not get quite so much milk as if they had lain in; but the udders are nearly always clean, which is an advantage to a milk seller."

We feel sure, however, that such practice would not generally be successful on our own farm in Cheshire, for example. The pasture is too damp to attempt leaving the animals out all winter. Probably some such plan as that of Mr. Nichol, described below, would obviate the difficulty. It is to be noticed, however, that the cows bore the cold well in the Newport experiments. The thermometer frequently stood below freezing, and on one night 25 degrees of frost were registered.

In his open-air experiments with tuberculous cattle (see p. 194), Dr. Rutherford[1] mentions that through an error of judgment on the part of an over-zealous herdsman the calves began to arrive in December, 1906, the first being dropped when the thermometer was 29° below zero, the others following at intervals, sometimes very short, until the middle of March, 1907. In spite of this, both dams and progeny throve well in the open air. "Nature has furnished our animal friends," says Rutherford, "with every conceivable requisite for protection against ordinary climatic conditions, and most of the diseases and disabilities to which they are subject have been caused by, and owe their continuance to, the irrational, artificial conditions imposed upon them by well-meaning but ignorant, or rather unthinking, owners and attendants."

Professor Douglas A. Gilchrist[2] describes several successful undertakings of breeding and rearing in the open air. The following is a reprint of Gilchrist's paper:—

"**PREVENTION OF TUBERCULOSIS BY OPEN-AIR TREATMENT.**

"As tuberculosis gives so much trouble in our herds of milch cows, a method of rearing calves so as to keep them clear of this disease is of great importance. The successful results obtained by Mr. A. F. Nichol, Bradford, near Belford, in this connection are, therefore, of great importance.

Mr. Nichol's methods

"Mr. Nichol has probably been one of the largest breeders of pedigree shorthorns in England for export, and as it is required that cattle, before entering many countries, must have passed the tuberculin test, the desirability of their being free from tuberculosis is apparent.

"Mr. Nichol's farms extend to nearly 1,000 acres. His herd of pedigree shorthorns now numbers about 100, including calves. The calving of his cows is so arranged that lots of from seven to eight calve at the same time. When near calving they are brought into one of the open folds near the homestead, where they calve. These folds are about 30 yards long by 20 yards wide. A narrow part along

1. 6th I. C. on T., Vol. 4, pt. 2, p. 878.
2. Reports of Dairy Investigations, Durham County Council, p. 140.

the north, east, and west sides is covered with a roof, and there is a back but no front wall. After calving, the cows and calves have the run of a pasture field and the shelter of an open fold when necessary. They remain on the pasture till October or November. The calves are then weaned and divided into lots, bulls and heifers being now kept separate. These lots are kept in open folds, where they are wintered. They receive during the winter some linseed cake, hay and turnips cut into fingers, and as much oat straw as they will eat. In these open folds the calves have all the advantages of open-air treatment in the first winter of their lives, and at the same time a considerable amount of shelter from the walls and roofs of the folds.

"The cows are in the fields during the whole winter, their only shelter being open folds and what they obtain from the hedges. Each field usually winters from seven to eight cows, and has an open fold, the gate of which is always open. This fold is about 25 yards long by 20 yards wide. The gate is in the middle of the south end. The fold is enclosed by walls from 7 to 8 feet high along the east, west, and south sides, and has on the north side a wall about a foot higher, along the south side of which a space about 10 to 12 feet wide is roofed over. This covered part has south walls at each end, where there are small enclosures railed off for straw, and these walls extend a few feet beyond these enclosures; otherwise the south side of the roofed part is open and has simply a pillar to support the roof.

"During the winter the cows at first receive straw only in addition to the pasture foggage, and about Christmas an addition of a small amount of rough cotton cake and crushed oats. As already stated, they come into the home folds to calve, after which they are fed more liberally. As each lot has gone together all the winter, they know each other, and do not fight and gore.

"Mr. Nichol, in over 20 years' experience, has never had an apparent waster in his herd, nor has he had any animal to react to the tuberculin test. He usually sells his young shorthorns for export at from 12 to 18 months old, and all have previously been so tested. He had 30 young shorthorns tested last year (1909) without a trace of reaction. Tuberculosis-free herd

"It is desirable that Mr. Nichol's plan of rearing calves, practically in the open air, should be followed in all our cattle-rearing districts in the north of England, in view of his success in producing animals which do not react to the tuberculin test.

"In this connection it may be noted that, on the writer's suggestion," Gilchrist continues, "a dairy farmer in North Buckinghamshire tested the whole of his cows with tuberculin in the year 1900. The cows in this herd were out on pasture practically all the year round, and were thus out of doors during day and night throughout the year. Only one animal reacted to the tuberculin test, and her history was doubtful. In this case also the great value of open-air treatment for preventing tuberculosis in cattle was demonstrated.

"Mr. Clement Stephenson, F.R.C.V.S., carries out this open-air treatment to a large extent in the management of his herd of valuable Aberdeen-Angus cattle at Baliol College Farm, Benton. In February, 1908, when the students from Armstrong College inspected his herd, he addressed them as follows :—

Keep close to Nature

"'If you wish to succeed as breeders of cattle you must keep as close to Nature as circumstances will allow, give the cattle wholesome food, and see that they have a supply of pure water in the fields as much as possible, and when in the house see that the buildings are adapted for the purpose. These should be well ventilated and lighted, no drains should open inside, but there should be an open channel through the byre that empties itself into a trap drain outside the building. The yearling heifers are wintered out, with a shed to go into if inclined to do so. The cows and two-year-old heifers are kept out up till calving time. The bulls also are kept in paddocks which have a shelter shed to the north during the summer. In winter they are kept in boxes with an open yard enclosed by a wall, the door between the box and the yard being always open. They have, therefore, open-air treatment all the year round.

"'Prevention of tuberculosis is better than cure, and, therefore, you should see to it that your cattle are living in a healthy atmosphere. If the air is pure the cold will not hurt them. At the same time we must remember that tuberculosis is an infectious disease, and, therefore, care must be taken that no animal affected with the disease is kept in the herd.'

"Practically the same method of rearing in the open air is carried out by Mr. T. H. Bainbridge, Eshott, Northumberland, in the management of his valuable herd of the same cattle. They are kept as much in the open air as possible, and the cattle have no other shelter than that of open sheds in the fields in winter; when the cows are brought indoors to calve they are kept in well-ventilated byres, and the young calves are with them for a few weeks after calving.

"The herds at Benton and at Eshott have always been remarkably healthy, and no doubt this is owing to the open-air treatment they receive and natural conditions under which they are kept."

Professor Gilchrist refers to a paper by Mr. Wade on cheap shelters and sheds for farms. An abstract of this paper will be found in Section III.

The evidence adduced by the American experts in the previous pages, showing that even under the best of range conditions tuberculosis spreads among bovines when the infection is present, seems to constitute a reply to the theory of Dr. Pickett Turner[1] that the disease can be eradicated by actinism, which is the power of the chemically active part of light. Turner assumes it is essential the cows should have some cover, and to permit of the transmission of the actinic rays of light,

1. Tuberculosis: Its origin and extinction, p. 83. London, 1906.

specially selected glass, he maintains (Turner, p. 84), should be employed. The beneficial effect of fresh-air treatment in human practice is ascribed to the stimulation of phagocytosis (Turner, p. 62). In the salubrious climates of California, Argentina, and New Zealand, however, the cattle enjoy the benefit of actinism in its full power, and yet the infection spreads when it is introduced. This being so, it is difficult to see how actinism could eradicate the disease among bovines in which it has secured a firm hold. Turner's direction of thought is undeniably sound, for light, as Letulle and Rey[1] have pointed out, "....is the originator *par excellence* of every perception and every vital action in man. In well-lighted surroundings life becomes exuberant; when the light begins to fail the vitality is lowered, and in complete darkness it almost disappears. While darkness favours the development of the most dangerous microbes, sunlight kills them. The direct rays of the Sun have a reparative action on the living cells of the body, and, therefore, constitute the most powerful factor in any *régime* for avoiding tuberculosis." [2]"The Sun is the fountain *par excellence* at which all people of the earth, without exception, must come to drink if they hope to live and prosper." All this is admitted by scientists, yet it does not appear that sunlight, although it undoubtedly checks the advance of the disease, can be relied upon to eradicate it, either in humans or in bovines.

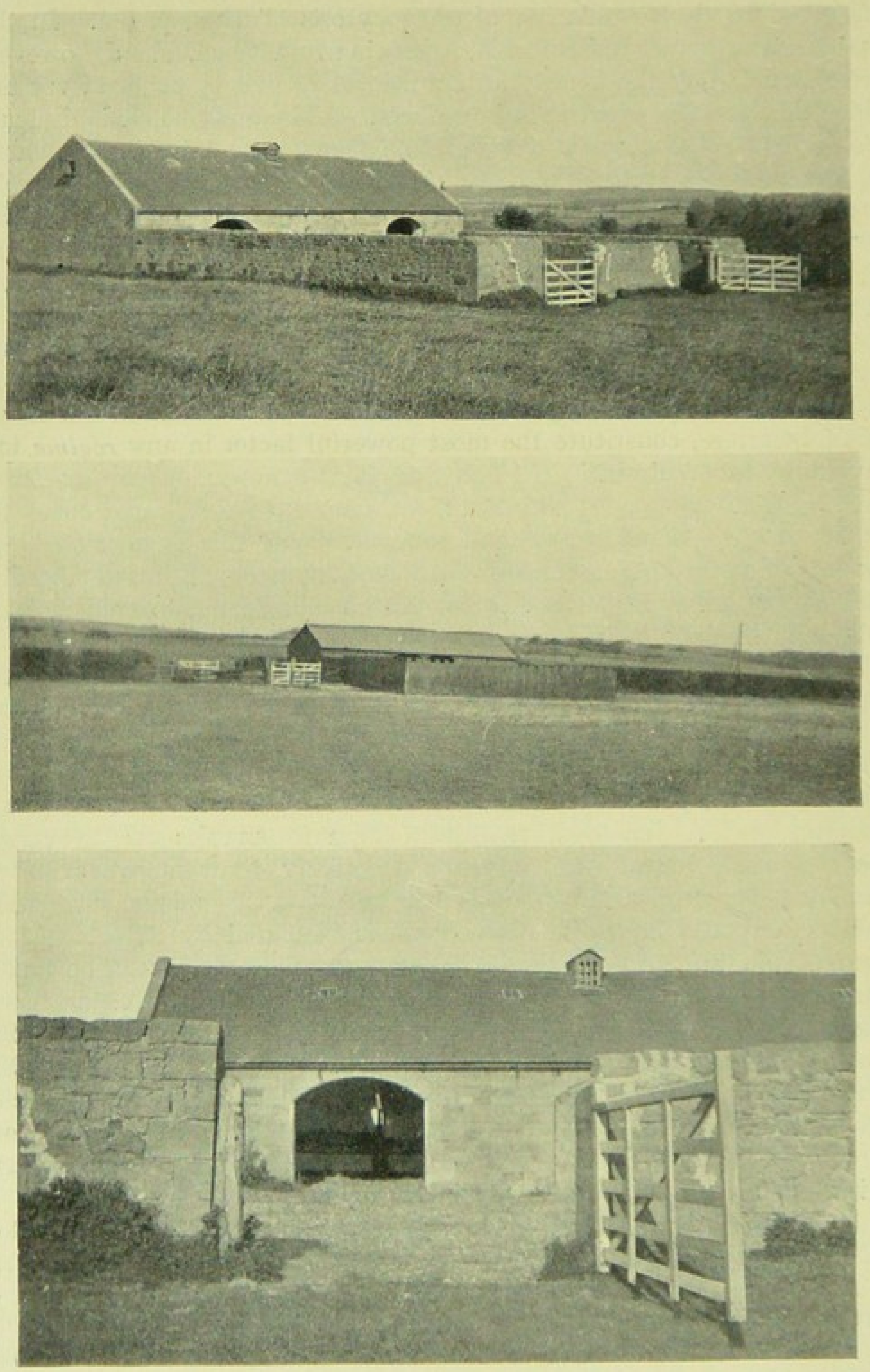
Sun cures tuberculosis

Certainly, as Amrein[3] reminds us, "During the last few years the 'sun cures' have begun to be known, and it is to be expected that a systematic and careful use of the sun rays will help us in the case of a great many different diseases. Tuberculosis, especially surgical cases, has been treated with sun rays already with excellent results, and....the high mountain climate enables us to carry out 'sunlight cures' much more effectively than anywhere else. And not only surgical tuberculosis may be healed by sunlight with good effects, but also laryngeal tuberculosis is benefited by it, often in a remarkable way. I have taught many of my patients to use the small laryngeal mirror themselves, and they let the sun rays enter their larynx systematically. The results are very good. And even certain cases of tuberculosis of the lungs may benefit in some degree by the use of sun baths, that is, by the exposure of the chest and back for ten to twenty minutes, but always with the utmost care. It is, of course, in all cases necessary to individualise and to exclude patients with a tendency to hemorrhages or who are generally weak."

British Wild Cattle Free from Tuberculosis.—It is interesting to note that until recently we had in Britain four herds of wild cattle. The following are the names of the owners: The Earl of Tankerville, Chillingham Castle, Northumberland; the Duke of Hamilton,

1. 6th I. C. on T., Special Vol., p. 234.
2. 6th I. C. on T., Special Vol., p. 236.
3. 6th I. C. on T., Vol. 1, pt. 2, p. 692.

PLATE XX.



VIEWS OF MR. NICHOL'S OPEN FOLDS.

Hamilton, near Glasgow; Captain Harrison, Aldersham, near Lichfield; Sir A. Cowell-Stepney, The Dell, Llanelly, Carmarthenshire.

Although complete and exact information is not available on the matter, the evidence we have succeeded in collecting goes to show that tuberculosis has never been found in any of these wild animals on slaughter. The only tuberculin testing which has ever been performed on these herds was that on six animals of the latter herd at a time when the whole herd consisted of eleven animals.

The six animals tested did not react.[1]

Turner[2] quotes Gresswell to the effect that in the wild state cattle never contract tuberculosis.

Domestication increases morbidity

The domestication of animals is undoubtedly attended with an increase in morbidity, especially wasting diseases, and notably in monkeys. Dr. C. Y. White and Dr. Herbert Fox[3] made an inquiry into this matter in the Philadelphia Zoological Gardens, where it had been noted "....that the average life of a common monkey on exhibition varied between eighteen and twenty-one months. It has been found upon examination that the great majority of these animals died of tuberculosis. What is true in Philadelphia is likely true in the zoological gardens in other parts of the world."

Letulle and Rey[4] relate that "In 1845 a place was built in the London Zoological Gardens to accommodate sixty monkeys. When they moved into their new dwelling all were in perfect condition. Some of them had lived several years in England without suffering the least impairment of health. At the end of one month fifty of them had died of tuberculosis, and the remainder were seriously ill. It was then found that the builder had neglected to provide for a constant renewal of air. These animals died of tuberculosis—killed by confined air."

Turner,[5] however, maintains that the monkeys in Regent's Park died from lack of actinism, and quotes Osler's confirmation that tuberculosis is unknown among monkeys and apes in a state of nature, but when domesticated it is most fatal to them.[6]

Russell and Hastings[7] state that "Most of the wild animals in captivity die of tuberculosis."

WHAT IS TUBERCULIN ?

What is tuberculin ?

Following its discovery by Koch, "The bacillus of tuberculosis," according to the last Royal Commission,[8] "being studied not

1. Private letter from J. D. Key, Esq., Tyngwern Farm, Llanelly, Dec. 14th, 1909.
2. Tuberculosis: Its origin and extinction, p. 48.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 591.
4. 6th I. C. on T., Special Vol., p. 225.
5. Tuberculosis: Its origin and extinction, p. 85.
6. Tuberculosis: Its origin and extinction, p. 48.
7. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 2.
8. Third Brit. Royal Commission on Tuberculosis, Second Interim Rept., 1907, p. 54.

only from a microscopical, but also from a chemical point, it was soon ascertained that the bacillus in the course of the physiological processes attendant on its growth and multiplication, gave rise to various chemical substances, some of which had a toxic (poisonous) effect when introduced into the bodies of animals. And it became recognised that the excretion of these toxic substances by the bacillus while it was setting up tuberculous processes in the body which it had invaded, played a not unimportant part in the development of the disease.

"These chemical products of the bacillus, toxic and other, were found to be present in artificial cultures of the bacillus, being chiefly at least retained in the bodies of the bacilli and capable of being extracted from these in the form of a solution by the appropriate use of glycerine and other reagents. To such a more or less purified solution of these products the name tuberculin was subsequently given.

Tuberculin as a prophylactic

"Koch was at first led to believe that the action of tuberculin, that is to say, of some or other of the products contained in the mixture called tuberculin, was antagonistic to the pathogenic activity of the bacillus, that if introduced into a body suffering from tuberculosis, it would arrest or even cure the disease. In this he proved to be mistaken; but the various observations on the effects of the administration of tuberculin brought to light this remarkable fact that a dose of tuberculin, which has little or no effect on a healthy body, produces a marked reaction, a disturbance marked among other symptoms by a distinct rise of temperature, when given to the same body suffering from tuberculosis. So clear and precise are these results that tuberculin has come into common use as a test for the presence of tuberculosis. If a certain dose (the dose differs with different animals) of properly prepared tuberculin be injected subcutaneously[1] into the body of an animal (or of a man), a subsequent marked rise of temperature may be accepted as a proof that the animal is suffering from tuberculosis."

The failure of Koch's tuberculin as a curative in the scourge of pulmonary tuberculosis was a deep disappointment to suffering humanity, but considerable hope is to be drawn from the experiences in the treatment of other forms of the disease.

Early mistakes

Dr. Nathan Raw,[2] consumption specialist of Liverpool, is very sanguine concerning tuberculin treatment. Certainly in the earlier efforts mistakes were made, so that the "....remedy was quickly dropped by the profession," but "....we now know that the only fault of the tuberculin was its dosage. It was a powerful remedy, and too large a dose was administered without the slightest scientific knowledge as to its action."

This procedure proved dangerous, [3]"....and although cases of

1. "Subcutaneously"—under the skin.
2. The Lancet, Mar. 26th, 1910, p. 846.
3. The Lancet, Mar. 26th, 1910, p. 845.

localised disease, such as lupus,[1] etc., were apparently cured, yet advanced cases of phthisis were certainly aggravated by this excessive reaction, with the result that the treatment fell into disuse and was for a time discredited. A few enthusiastic and scientific workers, however, revived the tuberculin treatment, amongst them being Spengler, Petruschky, Krause, and Thorner. The idea was to give tuberculin in small and graduated doses so as to avoid severe reactions, and yet ultimately to arrive at large doses by gradually producing an immunity in the tissues of the patient. This method has proved of immense benefit, and has met with striking success. Bandelier and Roepke describe it in the following words :—

Success claimed

"(1) 'It fulfils the first axiom in all medical treatment, *nil nocere*, and at the same time cuts the ground from under the opponents of the method.

"(2) 'It is in accordance with the demand to avoid reaction by using the minutest doses, and yet allows the highest and most potent doses to be reached.

"(3) 'It extends the indication for tuberculin treatment by bringing the severer forms within its reach.

"(4) 'It admits of the simultaneous and unhindered application of other well-proved methods of treatment, and may be carried out in out-patients' practice without sacrifice of occupation.'

"Denys himself reports," Raw continues, "favourable results in over 200 cases with his tuberculin."

Regarding the use of another special form of tuberculin prepared by Beraneck, Raw says "Results by many clinicians are favourable, and in cases of early pulmonary disease in conjunction with sanatorium treatment I have had excellent effects from this tuberculin," while concerning Koch's tuberculin "R" (new tuberculin), Raw finds "....a most beneficial and curative effect in treating all forms of so-called surgical tuberculosis," having effected "....a large number of apparent cures" by its use.

"I have now treated 28 cases of tuberculous peritonitis in patients varying from 3 to 37 years of age. I consider that tuberculin is an absolute specific in cases of tuberculous peritonitis where the disease is confined to the abdomen. Of the 28 cases 19 have been discharged quite recovered, 6 were much better, and 3 died."

"Forty-four cases of lupus have been treated with the most excellent results."

Tuberculosis a docile, curable disease

Raw regards "....tuberculosis as a most docile and willing disease to be cured," and believes that "....if we could only induce our patients to undergo treatment at the earliest manifestation of the disease in the body, our results would not only be more gratifying, but a vast amount of suffering and disfigurement would be spared. I do not for one moment think," Raw concludes, "that tuberculin

1. "Lupus"—tuberculosis of the skin.

is a cure for all forms of surgical tuberculosis, but in my experience it is the best treatment we have to-day. It often has to be associated with surgical procedures, and the intelligent co-operation of the physician and surgeon will often bring about a gratifying cure."

It remains for us to point out, however, that other medical specialists have not realised such favourable results as Dr. Raw. At a meeting of the Pathological Section of the Liverpool Medical Institution, March 10th, 1910,[1] Dr. Mackenna stated that he and his colleagues at the Skin Hospital were disappointed in tuberculin as a curative for lupus. Dr. Oram confirmed this view, while Dr. Henry Clarke disapproved of Dr. Raw's practice of treating tuberculosis of the lung with bovine tuberculin.

Dr. Crace Calvert, however, referred to his success with tuberculin as a curative. Just as in the treatment of humans with tuberculin many mistakes were made in the earlier attempts, so in the treatment of bovines some striking failures are recorded. Reference will be made to these under the head of Vaccination against Tuberculosis (see p. 386), in addition to the more hopeful results of Pearson and Heymans, which latter authority expresses his firm opinion that tuberculin *has* a curative effect.

Hammer[2] maintains that "....the use of tuberculin will always prove a strong weapon in the combat against tuberculosis." Dr. Theodore Williams,[3] London, was favourably impressed with the results of tuberculin treatment he saw at the Brompton Hospital and by his own experiments.

Pannwitz[4] states that "The results of the tuberculin treatment are becoming more and more satisfactory."

Dr. Pottenger[5] considers tuberculin "....is one of our best remedies if used intelligently."

Gabrilowitch[6] has obtained the most favourable results in chronic uncomplicated cases of pulmonary tuberculosis by the use of tuberculin.

Philip[7] finds that "....in the overwhelming majority of instances tuberculin has proved itself a therapeutic agent of first importance."

This Edinburgh authority speaks of the brilliant success of its remarkable power of limitation of tuberculous disease in the treatment of glands[8] and bones and joints.[9]

Wladimiroff[10] refers to the incontestable success of tuberculin treatment.

1. The Lancet, Mar. 26th, 1910, p. 862; also The Brit. Med. Jour., April 2nd, 1910, p. 812.
2. 6th I. C. on T., Vol. 1, pt. 2, p. 748.
3. 6th I. C. on T., Special Vol., p. 133.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 869.
5. 6th I. C. on T., Vol. 1, pt. 2, p. 948.
6. 6th I. C. on T., Vol. 1, pt. 1, p. 221.
7. 6th I. C. on T., Vol. 1, pt. 2, p. 804.
8. 6th I. C. on T., Vol. 2, p. 200.
9. 6th I. C. on T., Vol. 2, p. 201.
10. 6th I. C. on T., Special Vol., p. 142.

Is tuberculin specific ?

Denys,[1] also Maragliano,[2] claims that tuberculin treatment is specific for tuberculosis, but Meissen[3] maintains "It is not proved that tuberculin has a specific curative action. Neither animal experiments nor the results obtained in man justify such a conclusion."

Amrein,[4] however, states that "Careful tuberculin treatment shows most excellent results everywhere."

It is interesting to note that in Nebraska, State aid is extended only to those sanatoria using tuberculin.[5]

Kitasato[6] tells us that in his "....private institute for pulmonary tuberculosis, where patients are given chiefly tuberculin treatment, the number of cases recovered amounts to about 30 per cent." This result is not so good as results in Europe and America, but is due, Kitasato believes, "....to the comparatively large number of patients, already in an advanced stage of the disease, who came under his treatment."

A municipal tuberculin dispensary has recently been established in Portsmouth. Dr. Hilda Clarke,[7] in charge of the institution, has "....no doubt whatever that tuberculin is of the very greatest service in nearly all forms of tuberculosis, its use being only limited by the presence of complications. The only complication," she continues, "commonly met with that gives a contra indication to its use is systemic infection by other micro-organisms. In these cases it is often possible, by rest and fresh air, to reduce the importance of the secondary infection, and tuberculin can then be used.

"Other complications may render the progress of the case under tuberculin slow, and the result may appear unsatisfactory if the complication prevents the recovery of perfect health."

Oleic soaps

While touching upon cures for human tuberculosis, we may mention that Vaughan[8] contemplates the "....possibility that there may be found in the bacillary substance some constituent that may stimulate the cells of the animal body to split up and destroy tubercle bacilli."

Noguchi[9] finds that "The vaccination of guinea-pigs with the tubercle bacilli devitalised with oleic soaps develops in these animals a complete or partial resistance to a subsequent inoculation with a virulent culture of the same strain of *B. tuberculosis*. In short, a state of immunity against *B. tuberculosis* can be produced in guinea-pigs by means of injections of bacillary emulsion killed by oleic soaps."

Noguchi believes the action to be largely dependent upon the power of soap in dissolving the wax in the body of the bacillus.

1. 6th I. C. on T., Vol. 1, pt. 2, p. 771.
2. Quoted by Flick, 6th I. C. on T., Vol. 1, pt. 2, p. 807.
3. 6th I. C. on T., Vol. 1, pt. 2, p. 778.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 692.
5. See The Practitioner, Dec., 1910.
6. 6th I. C. on T., Special Vol., p. 17.
7. Private communication, dated June 13th, 1911.
8. 6th I. C. on T., Vol. 1, pt. 1. p. 229.
9. 6th I. C. on T., Vol. 1, pt. 1, p. 246.

Tuberculo-toxoidin

Following on the lines of Kitasato and Behring, who produced antitoxins for tetanus and diphtheria by first attenuating the virus by means of chemical reagents and immunising animals with it, Ishigami[1] applies the same principles to the tubercle bacillus and prepares tuberculo-toxoidin. The culture is soaked and washed with water to remove soluble toxin, dried, weighed, and rewashed. It is then treated with strong vitriol to disintegrate the bacterial body, extract the inner toxin, and change its toxicity. A large amount of water is added when the active substance settles as a precipitate. This precipitate is filtered off, washed, and dried. Half a gram is dissolved in 100 cubic centimetres of weak alkali to a brown-coloured transparent liquid—tuberculo-toxoidin.

It is found to be harmless on injection, and is as effective in immunising man and animals as Ehrlich's so-called tetanus toxoid. Hence the name "Tuberculo-toxoidin." Out of 772 tuberculous patients treated by Ishigami, 274 were completely cured and 258 partially cured.

Of 778 treated by other practitioners, 232 were completely cured and 228 partially cured.

Living tubercle bacilli

Webb, Williams, and Barber[2] immunise guinea-pigs and claim remarkable benefit in the cure of human tuberculosis by the injection of living tubercle bacilli, starting with a single organism.

Reviewing the recent results of Behring, Klimmer, also Pearson and Gilliland, Bang[3] considers it possible these attempts "....will lead to results of practical value, not only for cattle, but also for human beings, as Calmette and Guerin hope."

Among therapeutic methods, the following have been proposed and met with varying success: Intravenous injection of very dilute solutions of formalin, injection of Ehrlich's arsenical preparation No. 606, dioxydiamido-arsenobenzene dihydrochloride, sold under the more convenient registered name of "Salvarsan."[4]

Authoritative and comprehensible details of Dr. Szendefty's preparation are, as far as we are aware, not yet obtainable, but it appears that radium barium chloride, menthol, and iodine are the active constituents.

Still more recently attention has been attracted to the claims made for the exhalation of maggots—maggot gas. Remarkable cures are said to have been effected by breathing the atmosphere charged with the gas in which the active constituents are, seemingly, ammonia and trimethylamine.

Preparation of Tuberculin.—Russell and Hastings[5] state that in

1. 6th I. C. on T., Vol. 1, pt. 1, p. 248.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 211.
3. 6th I. C. on T., Special Vol., p. 220.
4. See "Salvarsan," or "606." Harrison and Westcott. New York, 1911. Paul B. Hoeber.
5. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 13.

preparing tuberculin "The tubercle bacillus is grown in beef broth (filtered beef tea) containing glycerine. After the maximum growth has taken place, the entire mass of broth and growth is heated to 212 degrees Fahrenheit for five to six hours. This kills the bacteria and serves to extract the contents of their cells. The dead cells are removed by filtration and the liquid evaporated to one tenth of its original volume. To preserve it carbolic acid is added, and it is then diluted for use. *It is impossible for the tuberculin to contain any living tubercle bacilli.*"

Various kinds of tuberculin are described by Calmette[1] as follows :—

Varieties of tuberculin

"The term 'tuberculin' is now applied not only to the glycerinated extract, originally obtained by Koch by evaporating down to one tenth of the original volume bouillon cultures of tubercle bacilli previously sterilised by moist heat and filtered through filter paper, but also to a number of analogous substances isolated from the same cultures by Koch himself, or by other investigators using various procedures. The nomenclature of these tuberculins has become exceedingly complex. Those which have been studied more than any others, except the old tuberculin or lymph of Koch, are the tuberculins T.A., T.O., T.R. tuberculocidine of Klebs, oxytuberculin of Hirschfelder, and the tuberculin of Denys, Weyl, Vesely, de Schweinitz, Dorset, and Beraneck.

Active principle of tuberculin

"As a matter of fact, the active substance is practically identical in all these various tuberculins. It is a proteid, the chemistry of which has not been determined, but which is readily purified by repeated precipitation and washing in 60 per cent. alcohol, beginning with the crude glycerinated lymph. I succeeded in obtaining it in its maximum activity by concentrating cultures *in vacuo* instead of sterilising them by heat. They are then filtered through several layers of thick paper and treated with five volumes of alcohol at 60°. The dried extract thus prepared is then purified by dialysis, thus eliminating the salts and the peptone. The final product, which is very soluble in water, has a toxicity almost ten times as great as that of the first alcoholic precipitate, and a hundred times that of crude tuberculin. The toxicity is measured by means of intracerebral[2] inoculation in a healthy guinea-pig. As a rule, 0·8 mg.[3] of this purified tuberculin suffices to kill a healthy guinea-pig weighing 500 grams,[4] while it requires 8 mg.[5] of the first alcoholic precipitate to accomplish the same result.

"Von Bergmann was the first to employ Koch's tuberculin as a means of diagnosing a tumour of the cheek which was suspected to

1. 6th I. C. on T., Special Vol., p. 76.
2. "Intracerebral"—into the brain.
3. 0·8 mg. = eight-tenths of a milligramme = one eightieth part of a grain.
4. A little over 17 ounces.
5. 8 mg. = one eight part of a grain.

be of a tuberculous nature (1890); but Koch had previously determined that the specificity of the substance is indicated by two characteristic phenomena, namely, a general febrile reaction and a local digestive action on tuberculous foci. When one centigram of crude tuberculin is inoculated into a tuberculous subject, these phenomena are so intense that they constitute a real danger; they bring about a mobilisation of the bacilli which sometimes leads to rapid generalisation of the process or the recrudescence of old foci that had almost become cicatrised. These dangerous properties of tuberculin, which have been observed and reported by large numbers of clinicians, will prevent its employment in the diagnosis of suspected lesions in man. We now know that by exercising caution in its employment accidents may be avoided. The investigations of Krause, Turban, Carl Spengler, Beck, Rumpf, and L. Guinard prove that the injection of measured doses, gradually increased until a feeble but distinct reaction is obtained, are harmless, especially in children."

According to Williams[1] "The T.R. tuberculin Koch produced by taking highly virulent cultures of tubercle bacilli, drying them *in vacuo*, and triturating them in a mortar. The resulting powder was treated with sterile distilled water and centrifugalised. The supernatant clear fluid was then removed, and to this Koch gave the name of T.O. (Oberertuberkulin). The solid residue was then again dried, and the same process of extraction repeated several times, the fluid used each time being preserved and the whole finally mixed together. This mixture constituted the residual tuberculin, T.R. (Tuberkulin Rückstand), which is now so much in use. Koch claims that in gradually increasing doses this confers immunity on guinea-pigs. The bacillary emulsion introduced by Koch consists of pulverised tubercle bacilli, one part to 100 of distilled water, with equal parts of glycerine, and is stated to be the best of all Koch's preparations."

"**Denys' Tuberculin.**[2]—This is made by filtering a culture of human tubercle through a porcelain filter. The culture is grown on peptonised and glycerinated bouillon and brought to full development. The object of Denys was to prepare a tuberculin which would produce a gradual and lasting immunity. By injecting healthy dogs with this preparation in increasing doses he was able to protect them against lethal doses of tubercle bacilli without producing any sign of the disease. The guiding principle of this treatment is the mild form of administration, avoiding all reactions and watching carefully the effect of each dose so as to find the tolerance of the patient to this particular tuberculin."

THE TUBERCULIN TEST.

When a small dose of tuberculin is injected into the body tissue of a healthy animal no effect whatever is observable. If the animal

1. 6th I. C. on T., Special Vol., p. 132.
2. See Raw, The Lancet, Mar. 26th, 1910, p. 845.

happens to be tuberculous the injection causes it to become feverish within a few hours following the injection. The indications of feverishness (febrile symptoms) are accurately detected and measured by observing the animal's temperature before and after the injection.

If a sufficiently large dose be used any animal, tuberculous or not, becomes feverish and is said to "react."[1] According to Wladimiroff,[2] "In the sound body one can administer considerable quantities of this poison without producing disturbance, but the infected body is so sensitive to the poison that an infinitesimal quantity of it causes the body to react with fever and general weakness."

[3]"As tuberculin is a product of tuberculous growth, it follows that it is constantly being formed when such growth is taking place, and when the disease reaches its later stages the quantity of tuberculin produced is sufficient to cause the afternoon fever, which is one of the characteristic symptoms of this disease, both in human and bovine subjects. While the disease is in its less active form, however, the system becomes gradually accustomed to the presence of the small amount of tuberculin produced, and the time comes when the ordinary dose of tuberculin fails to produce any reaction."

METHOD ADOPTED BY THE ROYAL COMMISSIONERS.[4]

How to carry out the tuberculin test

"The temperatures are taken at 10 a.m. for a varying period of from one to two weeks before the test, and no animal is tested unless its temperature is normal and regular, and it appears to be in every way in good health. On the day of the actual injection of tuberculin, the temperature is taken twice, once in the morning, and the second time at five o'clock in the afternoon. Immediately after taking the temperature for the second time the tuberculin is injected. The first record of the temperature after injection is taken six hours later, that is about 11 p.m., and after this the temperature is noted every three hours until five o'clock the following day. By this means a record of the temperature is obtained for a period of twenty-four hours after the injection of tuberculin."

VETERINARY METHOD FOR TUBERCULIN TEST.

In practice and for industrial purposes one does not demand the degree of precaution and exactitude of procedure adopted by our Royal Commissioners.

The following description of the practical method employed for the tuberculin test is abstracted mainly from Bulletin No. 199 of the California Agricultural Experiment Station by Ward and Haring, and the excellent work by the former expert, Pure Milk and

1. See Ohio Agri. Exp. Sta., Bull. No. 108, p. 294.
2. 6th I. C. on T., Special Vol., p. 143.
3. Ohio Agri. Exp. Sta., Bull. No. 108, p. 294.
4. Second Interim Rept., p. 43.

the Public Health, from which we have quoted freely in these pages. In the earlier days, when the tuberculin test was in the experimental stage, it was customary to take a series of normal temperatures of the cows during the whole day preceding the injection of tuberculin. The data thus obtained permitted the plotting of temperatures, before and after injection, in a most convincing way. The confinement of the cows for the day for taking these temperatures interferes greatly with the secretion of milk, and entails much extra work. These circumstances furnish a strong incentive for decreasing the number of these " normal " temperatures.

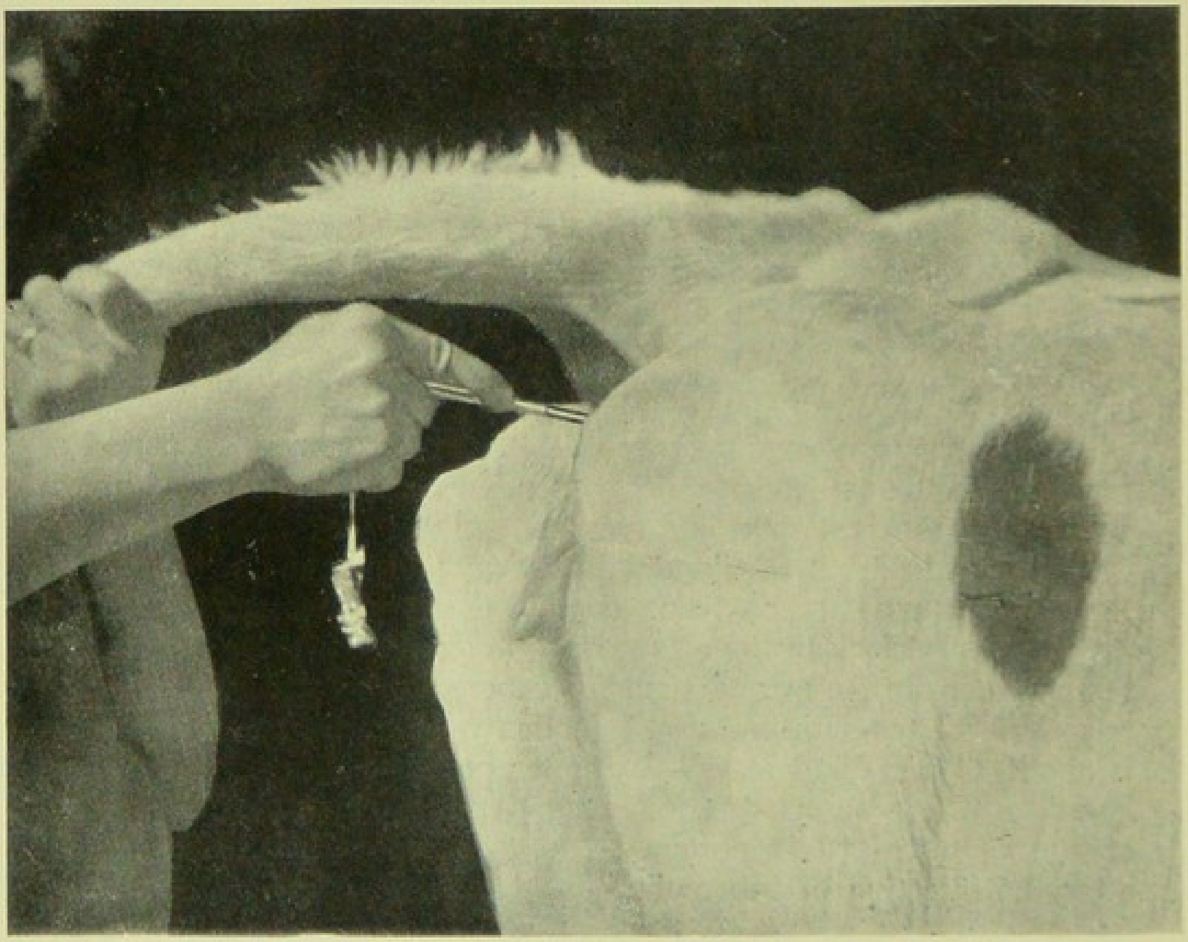


FIG. 5.—Manner of Taking the Temperature.

Temporary Numbers.—The identification of the cows during the test is satisfactorily accomplished by painting numbers on the rump with green paint. The numbers will in a few cases be smudged before drying, and the difficulty from this may be obviated by numbering all the cows in duplicate.

Russell and Hastings[1] recommend the use of gummed labels placed on the hair near the hips.

Facilitating Observations of Temperatures.—The observation of temperatures may be expedited by the use of several thermometers simultaneously. When more than one thermometer is used the risk

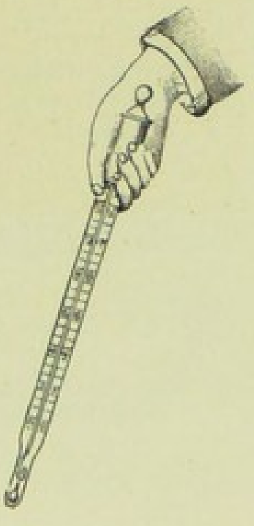
1. Wis. Agri. Exp. Sta., Cir. of Information, No 23, p. 16.

of breakage necessitates attaching the thermometer to the cow by a string. Special ring-top veterinary thermometers on the market facilitate tying a string to the thermometer. The human clinical thermometer may have a string attached to it through the medium of a rubber band firmly wrapped round the top.

Nervous cows will greatly delay the work by resisting the insertion of the thermometer. This may be obviated by enlisting the services of one of the milkers to stand at one side and pat the cow on the back.[1] Quiet, business-like work, with the minimum of delay and excitement of the cow, must always be kept in mind.

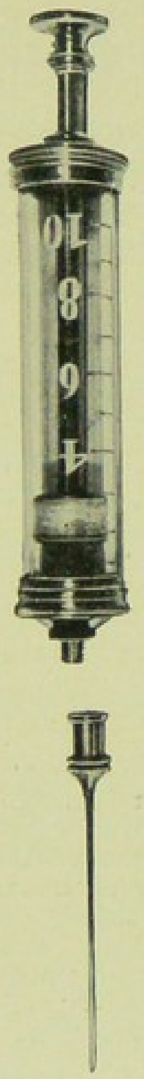
Taking the Normal Temperatures.—A convenient way is to take two temperatures, one at the morning milking and one in the evening, but it is preferable to take two more at two-hour intervals from the others. The last one may just precede the injection of tuberculin. Familiarise yourself with the reading of the clinical thermometer, and if trouble is experienced ask your druggist or doctor[2] to show you how. The largest intervals on the scale are degrees, of which every second one only is numbered. The smaller intervals designate 0·2 of a degree. Readings can be made accurately to half of one of these smallest divisions, 0·1. Insert the thermometer full length in the rectum.[3] Smear the bulb of the instrument and the end of the

1. Russell and Hastings (Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 15) recommend scratching with curry comb.
2. We suggest the veterinarian. A few words regarding the manipulation of thermometers may not be amiss in this place. Before taking a temperature one must make certain that the top of the mercury column is below the mark it is expected to rise to in the test. This must be secured without shattering the column, and is attained by throwing it down by centrifugal action rather than by jerking or tapping. In case the mercury is found splashed in the bore, it may be necessary to warm the reservoir carefully, say in warm water. The column will then rise and join up with all the minute beads, that is, if moisture, air, and dirt are absent; but the presence of any appreciable amount of these will effectually prevent the cohesion of the metal into a continuous thread (all thermometers contain a little air). In defective thermometers one finds a portion which persistently refuses to join up. Such an instrument should be rejected. Nowadays, however, even cheap instruments are usually free from such gross imperfection. To depress the column of mercury, take firmly hold of the top end and throw the reservoir end downwards without allowing either the hand or the instrument to touch any object. A little practice will enable the beginner to discover the way the mercury moves. The accompanying sketch shows the motion for a larger size of thermometer than the clinical instrument. If the mercury happens to have run into the safety chamber at the top, it may be necessary to attach the instrument to a string and whirl it into the bore. (Figure above is reproduced from instructions issued by W. Holzhauer, Marburg.)



3. Von Behring recommends that before introducing the thermometer the rectum should be cleared of any hard fæcal masses (see The Suppression of Tuberculosis, translated by Bolduan, p. 70).

PLATE XXI.

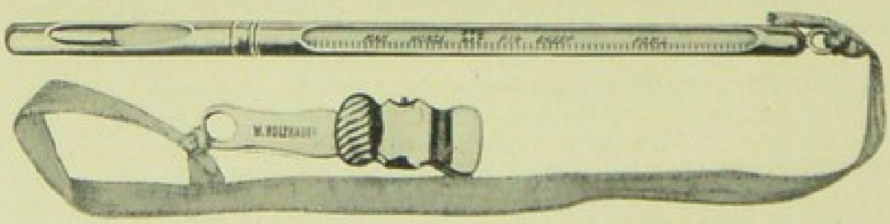


Ordinary Syringe with Asbestos Plunger.

Sealed Glass Tube containing tuberculin for ophthalmo test.

Sealed Glass Phial containing a dose of tuberculin.

Syringe with Glass Plunger.



Prof. Hobday's Metal Cased Veterinary Clinical Thermometer with Tape and Clip.

PHOTO.] [J. MURGATROYD.

INSTRUMENTS FOR THE TUBERCULIN TEST.

index finger with vaseline to facilitate the operation. Attach the thermometer to the base of the tail by means of the snap, or a wire hook and rubber band,[1] and allow the thermometer to remain in the rectum three minutes.[2]

By the use of this device three or four thermometers may be used, and the temperature of several animals taken in the time that is required to take one. Be sure and shake down the mercury below 99° Fah. each time before inserting the thermometer in an animal.

After the temperature is read, the thermometer is inserted in a pot of vaseline[3] until needed for use next time. If there is no convenient ledge at the rear of the cows, a light portable box about a yard high forms a convenient stand for the vaseline and thermometers.

"The utmost care should be exercised," says Marshall,[4] "in sterilising thermometers, needles, syringes, hands, clothing, etc., before and during the time of making a test. Contagious abortion, tuberculosis, and other contagious diseases may be carried from animal to animal or from herd to herd if this precaution is not taken."

Temperature of Cattle.—The usual normal temperature of a milk cow varies between 101° Fah. and 103° Fah.,[5] but it is not uncommon to find apparently healthy cows that temporarily are even lower or higher than these limits. Excitement may cause a temporary rise, excessive summer heat also increases the normal temperature,[6] while the drinking of cold water may reduce the temperature a degree or two. Marshall[7] says "Water can safely be given soon after a temperature has been taken, but it should not be allowed freely just before a temperature measurement. In stables where there is a constant water supply there is no danger of the animals taking enough to interfere with the temperature."

The following table by Russell and Hastings[8] will give an idea of the variations in temperature that may be noted in the same animal. There is also included the pulse rate and number of respirations per minute.

1. As this insertion of the thermometer not infrequently gives rise to defecation.
2. In this country veterinarians use half-minute thermometers. Russell and Hastings, however, state that "The 'one-minute' thermometers, *i.e.* those registering in that time, are too fragile for general use in testing cattle. The 'two-minute' veterinary thermometer is preferable. It may be used with or without an open metal case. The case protects the thermometer, but causes it to act more slowly and makes it more difficult to read" (see Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 14).
3. We should prefer carbolised vaseline, to prevent possible infection being carried to the next animal.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
5. We consider 102·5° Fah. the maximum temperature for normal bovines.
6. Marshall (6th I. C. on T., Vol. 4, pt. 2, p. 907) says "Tests in hot, sultry weather may not be satisfactory. So far as possible, it should be arranged to do the testing in the cooler parts of the season."
7. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
8. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 13.

THE INITIAL TEMPERATURE OF TWO COWS, WITH RATE OF PULSE AND NUMBER OF RESPIRATIONS PER MINUTE.

Hour.	Cow No. 1.			Cow No. 2.		
	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.
9 a.m.	99·8	48	18	98·6	48	15
10 a.m.	99·5	66	18	98·6	60	15
11 a.m.	99·0	60	15	99·0	60	15
12 noon.. ..	100·8	54	15	99·4	54	15
1 p.m.	101·4	54	15	100·0	54	18
2 p.m.	101·6	48	15	100·2	54	18
3 p.m.	102·0	60	24	100·4	72	24
4 p.m.	103·0	66	24	102·7	72	24
5 p.m.	103·3	66	24	102·8	72	27
6 p.m.	103·1	57	18	103·0	60	27
7 p.m.	102·2	60	20	102·4	60	24
8 p.m.	103·0	56	16	102·0	60	24
9 p.m.	103·1	52	24	102·2	50	24
10 p.m.	102·5	60	20	102·0	50	18
11 p.m.	102·5	60	20	102·0	60	20
12 midnight ..	102·4	56	16	101·6	54	20
1 a.m.	101·8	60	20	101·4	58	24
2 a.m	102·0	64	18	102·2	58	18
3 a.m.	102·0	60	18	101·6	58	18
4 a.m.	102·2	54	24	101·5	60	24
5 a.m.	101·6	56	24	102·0	60	18
6 a.m.	101·8	60	18	102·2	60	20
8 a.m.	102·5	56	16	103·2	60	18

Resuming Ward and Haring's account, " Most cattle are at their lowest early in the morning and highest in the afternoon. After exposure to a storm or during the severe north winds which sometimes occur in Central California, the temperature of the cattle is frequently quite high. The temperature of calves under four months old is much more variable than that of older cattle."

Treatment of Animals during the Test.—On account of the ease with which variations in temperatures are caused, it is important to keep the animals that are being tested under normal conditions. They should be fed, watered, and milked[1] as usual. Avoid as much as possible the violent handling of nervous cows in taking their temperatures.

Animals that should not be Tested.—According to Marshall[2] " The test should never be applied unless the animals are quiet, contented, and undisturbed." [3]" It is best, by all means, to start with a normal

1. And stabled as usual, according to Marshall (6th I. C. on T., Vol. 4, pt. 2, p. 907); also protected from draughts, according to M'Fadyean (Directions for Using Tuberculin, Research Laboratory, Royal Veterinary College, London).
2. 6th I. C. on T., Vol. 4, pt. 2, p. 906.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 907.

initial temperature." Ward and Haring say: "Cattle suffering from any disease causing a fever (garget, 'foxtail abscess,' retained after-birth, etc.) should not be tested until the fever has subsided. If the cattle have been recently injected with tuberculin, a re-test within one month will be unreliable, and it is safer to allow six or eight weeks to elapse."[1]

Russell and Hastings[2] include among the animals that should not be tested "Those that show a single temperature before inoculation of 103·5° Fah., or above. Calves and fat stock may have a normal temperature of 103 to 103·5° Fah., and may be tested if all of the temperatures are uniformly high. It is not considered wise to test calves under three months old."

Ward and Haring continue: "Most authorities state that the test should not be applied to cows within four days of calving, or during the period of heat, for fear that these conditions might cause a rise."

According to Marshall,[3] "Advanced stages of pregnancy seem to make little, if any, difference with the test. Many successful tests have been made during the day of parturition."

Mohler,[4] however, considers that advanced pregnancy may be a cause of failure of the test,[5] and in addition to the before-mentioned disturbing factors, mentions (1) the excitement of œstrum; concurrent diseases, as inflammation of the lungs, intestines, uterus, udder, or other parts; indigestion, etc.; (2) inclosure in a hot, stuffy stable, especially in summer, or exposure to cold draughts or rains; (3) any change in the method of feeding, watering,[6] or stabling of the animal during the test. It is usual practice, say Ward and Haring, "to inject all animals and take the above-mentioned conditions

1. Further experience has convinced Ward that six weeks is not sufficient (see p. 254 footnote).
2. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 19.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
4. P. H. and M. H. S., Bull. 56, p. 511.
5. Russell and Hastings (Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 19) confirm this and include those animals that have just calved, especially when the afterbirth was not discharged in a normal manner, also those animals that have aborted within a short time.
6. Russell and Hastings (Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 18) state that "If an animal drinks a large amount of cold water, the temperature will be lowered. It is possible to have fever produced by the tuberculin, and, due to the drinking of a large amount of cold water, the temperature so lowered that the fever will not be detected. This may lead to incorrectness in interpreting the temperatures, and a cow may be passed as healthy when in reality she is diseased. If the water can be warmed, it can be given in any amount. If cold water must be used, and the animals are generally watered during the morning, when temperatures are being taken, a pailful may be given to each animal at periods of an hour or so, preferably immediately after a reading has been taken. The small quantity will not affect the temperature. Care should also be taken that none of the preliminary temperatures are lowered by the watering."

into consideration, and re-test if a rise in the temperature does occur."

Russell and Hastings[1] state that "If the daily routine is not such as will enable the test to be made conveniently, change a week or ten days before the test is to be made, so that the cattle may become accustomed to it." Professor Sir John M'Fadyean[2] places the duration of the preliminary housing at two or three days.

The Best Time to Test.—"The most convenient time to test the herd," according to Russell and Hastings,[3] "is while the cattle are in the stable, shortly after they are put up for the fall, or in the spring. It can be done at any time during the winter, but not so conveniently in very cold weather.

"During the summer the cattle must be taken out of the pasture and kept in the stable. This causes them to become uneasy. During very hot weather, the temperature of the cattle may be high, and may lead to errors. If it is necessary to test during the summer, it can be done, but the work can be done more satisfactorily during the fall and winter."

[4]"**Making the Injection.**—This is preferably done in the evening, eight[5] hours before the time of milking in the morning. The syringe, should be disinfected by drawing it full of carbolic acid, emptying it, and then rinsing in boiled water before beginning the test. In addition to this, just before injecting each animal, dip the tip of the syringe in strong carbolic acid to disinfect it. Fill the syringe[6] through the needle from the bottle of tuberculin, and avoid contaminating it with dirt. Set the burr on the piston rod of the syringe so that not more than the dose intended can be injected. The large numbered divisions on the syringe piston rod stand for cubic centimetres (c.c.). The size of dose will be stated on the tuberculin bottle.[7] The injection is usually made in the side of the neck where the skin is thin and loose. A fold of the skin is taken in the left hand, and the syringe point

1. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 17.
2. Roy. Agri. Soc. of Eng., Proc. of Monthly Council, Feb. 22nd, 1911, p. 24.
3. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 19.
4. California Agri. Exp. Sta., Bull. 199, p. 229.
5. In a later work Ward says ten hours. See Pure Milk and the Public Health, p. 79.
6. "In filling the syringe, care should be taken to avoid getting air into the cylinder, and in emptying it a steady pressure should be used (Ohio Agri. Exp. Sta., Bull. 108, p. 293). Russell and Hastings recommend the use of those syringes of which the needles slip on rather than screw on. Both these forms of needle attachment are shown in Plate XXI. (p. 218). "This enables the operator to insert the needle before it is attached to the syringe, and thus decreases the danger of breaking the needle if the animal moves. The needles should be kept sharp by whetting on an oil stone in order that they may be inserted easily."
7. The usual dose is 2 c.c. "Yearlings and two-year-olds, according to size, should receive 1 to 1½ c.c., while bulls and very large animals may receive 3 c.c." (Mohler, P. H. and M. H. S., Bull. 56, p. 574).

inserted in the pocket thus formed, and the dose injected.[1] When a cow is restrained in a stanchion the position of the operator shown in figure ensures the greatest security from interference or injury by the movements of the cow."

Macewan[2] recommends "Great care and attention to cleanliness ....in performing the test. The operator's hands should be thoroughly

FIG. 6.—Manner of Injecting Tuberculin.

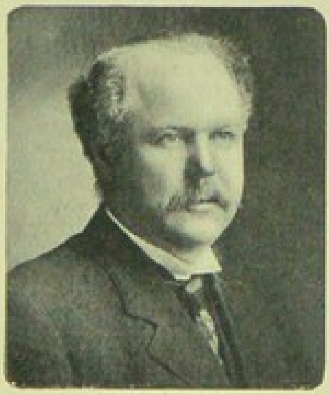
washed and steeped in some antiseptic solution. Before injecting the tuberculin, the hair of the animal to be tested should be clipped close to the skin at the place where the injection is to be made, and the skin itself well washed and rubbed with a piece of gauze or other material soaked in a solution of corrosive sublimate—1 in 500—or other antiseptic solution."

1. On the chest wall behind the point of the elbow is also a suitable spot. "The tuberculin must be injected into the subcutaneous connective tissue, and care must be taken that the whole dose is introduced" (M'Fadyean, Directions for Using Tuberculin, Research Laboratory, Royal Veterinary College, London). Russell and Hastings (Wis. Agri. Sta., Cir. of Information, No. 23, p. 16) direct that "The skin is lifted up with one hand and the needle thrust through at right angles, but parallel to the side of the animal, so that the contents of the syringe may be discharged underneath the skin, but not into the muscles."
2. The Public Milk Supply, p. 25.

Professor Sir John M'Fadyean[1] says "The tuberculin should be kept in a cool place and protected from light. Should it become turbid or cloudy, it must not be used." "When there is any reason to suppose that the animal may have been already tested with tuberculin during the preceding two or three weeks, it is advisable," according to M'Fadyean, "to take the temperature at the third and sixth hours....."

[2]"**Temperature after Injection.**—Take temperatures at about 8th, 10th, 12th, 14th, 16th, and 18th hours[3] after injecting, and continue in those cases showing a rising temperature. Where an animal shows a rise above 102·5° Fah. it is well to take the temperatures at more frequent intervals. In hot weather it is essential that the injection be timed so that the 8th to 16th hours will occur in the cool part of the day.....In case of a reaction (indicating the presence of tuberculosis) there must be a rise of 1·5° Fah. or more above the normal temperature as determined on the preceding day. The interpretation of the temperature record of the animals showing a rise of less than 2° Fah. requires care."

According to Marshall,[4] "The point at which a reaction is considered positive is a relative quantity. A temperature that rises



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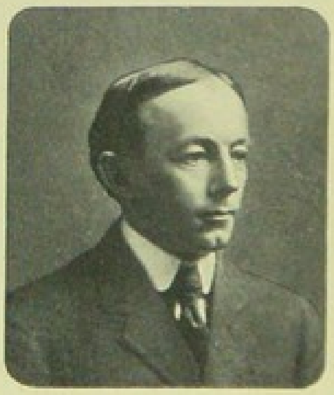


DR. E. G. HASTINGS
Associate Professor of Agricultural Bacteriology and Bacteriologist of the Experiment Station, University of Wisconsin, Madison, Wisconsin, U.S.A.

gradually from the 8th to the 16th hour from 102° to 104° or above, under ordinary conditions, can be considered a positive reaction." Melvin[5] states that "A reaction consists of a rise of 2° Fah. or more above the highest temperature before injection, provided the maximum temperature after injection reaches 103·8° Fah."

Russell and Hastings[6] state that "....if the highest temperature after the injection is 2° Fah., or more, above the average normal, the

1. Directions for Using Tuberculin, Research Laboratory, Royal Veterinary College, London.
2. California Agri. Exp. Sta., Bull. 199, p. 230.
3. Brittlebank continues to the twentieth hour. (Private communication.)
4. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 506.
6. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 19.

animal is generally regarded as having given a positive reaction..... When the rise is close to 2° Fah. and the temperature not above 104° at any time, the reaction is classed as doubtful. In all cases, and especially in the doubtful ones, the interpretation of the records should be made by an experienced person, who should be furnished with all the information possible concerning the condition of the animals, the age, whether raised or purchased, whether from a healthy or diseased herd, the number of reacting animals in the herd tested, whether tested previously or not, etc. The positive tuberculin

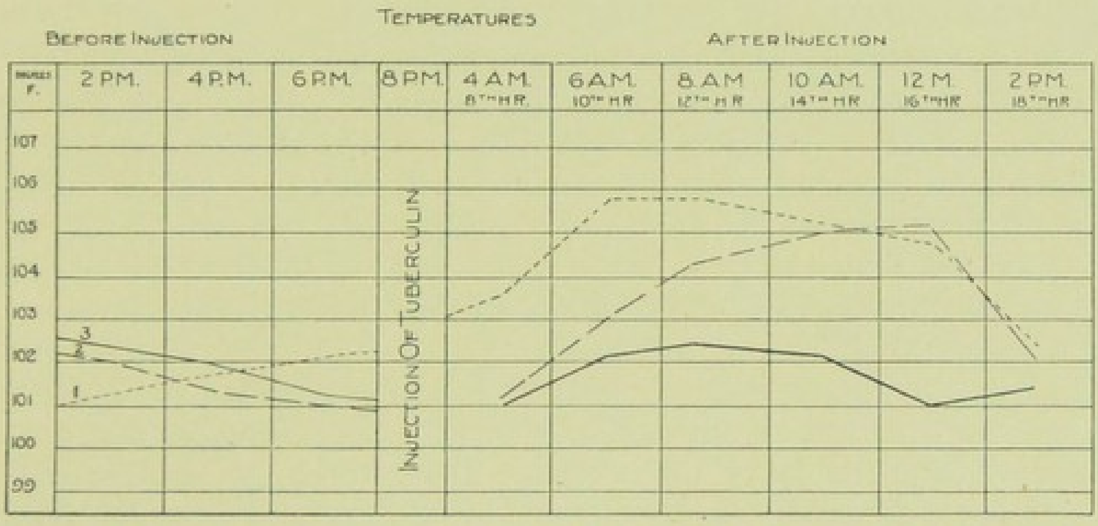


FIG. 7.—Typical Temperature Curves: 1 and 2 of tubercular animals, 3 of a healthy animal.

reaction generally shows a regular rise, the temperature remaining at the highest point for only a short time, then falling gradually to the normal. The decline is usually more rapid than the rise, although exceptions are noted. The character of the curve should also be taken into consideration. A widely fluctuating temperature, say a high, then low, and later a high temperature, is not a characteristic curve and should be classed as doubtful rather than as a positive reaction.

"Are any other changes to be noted in a reacting animal other than the rise in temperature?—Some of the reacting animals show the effects of the tuberculin by shivering, staring coat, refusal to eat, etc. In some cases these symptoms are very noticeable, in others they do not appear at all. In the case of non-reacting animals, no such symptoms are ever noted. There is also frequently to be noted at the point of injection, a slight swelling in the case of reacting animals, but usually this is so slight that it is not noticeable."

Discussing the State-aided measures in America for suppression of bovine tuberculosis, Reynolds[1] is of opinion that "The sanitary authorities should define fully and in detail just what constitutes a

1. 6th I. C. on T., Vol. 4, pt. 2, p. 946.

tuberculin test which will be accepted, and every test record should be accompanied by an affidavit from the one who signs the test records ; which affidavit should specify just what and how much the affiant did in connection with the test."

Returning to the account by Ward and Haring, we find that " The elevation of temperature usually comes on gradually, although in the more pronounced reactions, where the temperature goes above 105·5° Fah., the rise is frequently abrupt. This should usually occur between the 8th and 16th hours. It should remain practically at a maximum for two hours or more and gradually subside." Marshall[1] says " In well-marked reactions, the temperature may rise to 107° or higher. This is more liable to occur in cases of recent infection or where the disease has not become generalised." Ward and Haring continue : " When the temperature reaches 104° Fah. or more, and is maintained for some hours, the animal is certainly regarded as tubercular, if no fever was shown before the injection. Erratic elevations of short duration do not indicate a reaction. The slight variations caused by the weather, the drinking of cold water, or the irregular handling in applying the test are as apparent in the temperature records of the non-reacting cows as in the others, and a comparison of the temperatures of the animals which show no indication of a reaction should be taken into account in interpreting the records.

" In case of doubt the animal should be separated from the herd and re-tested not sooner than a month."[2] Marshall[3] says "....in about two months," and " in this case a larger dose of tuberculin should be used. It may be advisable to use three or four doses at one time. In advanced cases of tuberculosis, or where the disease is suspected from a physical examination, a rise of one degree should be interpreted as a reaction. In herds where a large number of reactions have been obtained, the line may be drawn more closely on doubtful cases."

Observe carefully

Rutherford[4] deplores the present-day neglect of clinical diagnosis of bovine tuberculosis. " This state of affairs," he says, " is regrettable and should be remedied by cultivating, with regard to cases of tuberculosis, that habit of painstaking observation which alone makes for success in the diagnosis of most of the other maladies to which dumb animals are subject."

Brittlebank[5] confirms this view, attaching great importance to observation of the animals during test.

Rutherford says " Among the temporary signs which may be noticed, as a rule, from six to twelve hours after injection are, in severe cases, rigors, often accompanied by staring coat, general excitation,

1. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
2. See footnote 2, p. 254.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 907.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 873.
5. Private communication.

and frequently diarrhœa. In less well-marked cases we have coldness over the loins, quarters, thighs, and tail, subacute excitation, and general malaise. Even when these symptoms have passed off, the animal maintains a standing posture and is more or less stiffened; there is loss of appetite, rumination is suspended, and in milch cows the flow of milk is diminished. Close attention to and observation of the animals undergoing the test are, in my opinion, indispensable. Even with them it is possible for mistakes to be made; without them, the tuberculin test is very apt to be badly discredited."

Resuming Ward and Haring's account. If all conditions pertaining to the protection of the animal have been fulfilled, the temperature behaviour mentioned is a very sure indication that the animal is suffering from an active, although possibly a very small, tubercular growth. If there is no reaction, the correct interpretation is more difficult. Dr. V. A. Moore, of the New York State Veterinary College, says that in this case there are three conditions which must be taken into account, viz.—

Interpretation of negative results

(1) If the animal is extensively diseased it may, in rare instances, not react. In this case the physical condition would show that the animal was at least not healthy.

(2) If the test was made during the period of incubation there would be no reaction, although the disease might soon develop. (By a period of incubation we mean the time elapsing between the exposure to a disease and its actual development. In tuberculosis this period is very variable. In some cases the disease begins to progress at the day of infection, in others the germs may be lodged for a long time before the disease actually develops.)

(3) It is known that cows which have reacted, may, because of the natural arrest of the disease, fail to react subsequently; but later the disease would start up again, when the animal would react. Great care must be exercised, therefore, in the interpretation of negative results, especially tests made in herds where tuberculosis exists, and where it is possible that the animals failing to react have been infected.

Physical examination for non-reactors

With regard to the animals which have not reacted, Salmon[1] directs that these "....should be submitted to careful physical examination, and those which are emaciated, or have abnormal sounds in their lungs, or are frequently in heat, or which cough or have digestive disturbances, should be regarded as probably affected. The udder should also be examined with great care, and if hard, painless swellings are found in one or more quarters, and particularly if a hind quarter is affected, the trouble is probably caused by the *Tuberculosis Bacillus*. By this careful physical examination the cows in a more or less advanced stage of the disease, which fail to react to the tuberculin test, may be detected, and measures taken to prevent the disease spreading from them."

1. B. A. I., Bull. 38, p. 48.

Re-testing.—A single test of a diseased herd cannot be depended upon to detect every tuberculous animal.[1] If any animals are found by the first test to be affected, the herd should be tested regularly every six months.[2] On account of the many chances for the infection of a herd, the practice of systematic annual testing is recommended for all dairy herds. Animals purchased subject to the test should be re-tested in four or six months. As has already been mentioned, a re-test within a month is unreliable, and when animals are re-tested within six months it is better to use a double dose (4 c.c.) of tuberculin.

Russell and Hastings[3] state that doubtful reactors should not be re-tested ". . . . for at least sixty days, as a tuberculous animal will not react to a second dose of tuberculin injected soon after the first. Time must be given for the original tuberculin to be eliminated from the system. When re-tested a *triple* dose should be given."

[4]" If the percentage of reactions is not more than from two to five, and the sanitary conditions are good, the re-test can safely be left for a year. In large herds the test should be made at least once a year, even though it has previously passed with no reactions." Bang[5] adheres to this practice (see p. 292).

SHOULD FARMERS DO THEIR OWN TUBERCULIN TESTING ?

Rutherford says " No"

Dr. Rutherford,[6] Ottawa, Canada, considers that ". . . . only skilful and specially trained men can with safety be employed in this work." C. J. Marshall, V.M.D.,[7] Philadelphia, agrees that " Any intelligent person can soon learn to use a hypodermic needle and a thermometer. There are other things about the tuberculin test that are more complicated, and at times men the most skilled in its use are put to their wits' end to know how to handle peculiar questions that arise in connection with this subject. It would be as easy, and far safer for the community, to try to teach the average

1. " Neglect of this in the past " says Professor Sir John M'Fadyean (Jour. R. A. S. E., 1910, p. 39), " has probably been more responsible than anything else for disappointment and partial failure in attempts to eradicate the disease."
2. Professor Sir John M'Fadyean (Jour. R. A. S. E., 1910, p. 40) says the second test should certainly not be delayed beyond three months. Moreover, it is important that the interval between the subsequent tests should not be longer than six months (Jour. R. A. S. E., 1910, p. 44). " The only persons who can expect to attain immediate and complete success are those who are able to dispose forthwith of all the animals found to be diseased on the occasion of the first test. Even these may not be immediately successful, but by taking advantage of the combined methods of testing, recently introduced, it will generally be possible to weed out the last of the diseased animals at the second test, that is, within three months " (Jour. R. A. S. E., 1910, p. 44).
3. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 21.
4. Marshall, 6th I. C. on T., Vol. 4, pt. 2, p. 906.
5. Private communication from Professor A. R. Ward.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 873.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 904.

farmer to be his own blacksmith, wagon builder, lawyer, physician, etc., as to instruct him to do his own testing for tuberculosis."

Many competent authorities are in favour of administrative control of tuberculin testing and its limitation to qualified and duly appointed veterinarians. This contention has resulted mainly from the deplorable, fraudulent practice of "doping" or "fortifying" animals so that they will not react even if diseased. The late Professor Owen Williams was a strong advocate of this view.

Williams concurred

Regrettable disclosures of dishonest procedures have certainly been too frequent in connection with the export trade of British cattle to the Argentine and other parts of America.

Great interest centres, however, around the action of the Wisconsin authorities concerning [1]".... the general distribution of Bureau tuberculin to parties making application. The Wisconsin Experiment Station [One of the most famous experiment stations in the world, be it noted.], in connection with the Sanitary Board, furnishes tuberculin freely and gives instructions for testing to their agricultural students, short-course students and others, and these are encouraged to do general testing. Satisfactory information has not been obtained concerning the practical working of this method; but it seems quite certain that a State can hardly continue long to pay, directly or indirectly, indemnity to owners on tests so made, even though the records may be reviewed by the State veterinarian's office."

Wisconsin authorities say "Yes"

After reciting some figures, Reynolds continues, "It is thus seen that approximately two-thirds of the testing done in Wisconsin during the past year has been done by farmers, short-course students, dairy-course students at the Agricultural College, and farmers in general."

The authorities of Michigan Agricultural College Experiment Station[2] state that "The test may be mastered by any bright young man who may wish to study into its details."

Later on in his paper Reynolds[3] says, "States doing serious work with tuberculosis have had quite enough trouble with tuberculin tests done by veterinarians who know how the work should be done. It does not appear wise to extend this trouble by throwing such work wide open to students and farmers in general, with the State to pay for cattle condemned on such basis, even though some veterinary officer does look over the test records."

The question that Reynolds raises is not so much the desirability of the farmers doing the testing as the wisdom of the policy of the State paying indemnity on the results.

When, however, we study the interesting and valuable computations the same authority places before us regarding the magnitude

If not the farmer, who?

1. Reynolds, 6th I. C. on T., Vol. 4, pt. 2, p. 929.
2. Circular No. 8, p. 63.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 940.

and expense of efficient State tuberculin testing, one may naturally wonder whether it is likely to be done in reasonable time if the farmer does not undertake it (see p. 353).

Dr. A. T. Peters,[1] Department of Animal Pathology, University of Nebraska, speaking of his own experiences, says "We have records of 386 head of cattle that were tested by the owners themselves, formerly agricultural students. The students did the work themselves, and copies of the temperature sheets were sent to us for verification. Out of this number there were 29 head, or 7·51 per cent., condemned by our department, 18 of which have been reported to us as having been killed and found to be tubercular. I mention this to show that the tests were made quite accurately by the students themselves."

Dr. Eastwood's Report

One of the expert pathologists in the employment of our Royal Commission on Tuberculosis—Dr. Eastwood—was attending the International Congress on Tuberculosis, in Washington, 1908. The President of the Local Government Board—the Right Hon. John Burns, M.P.—gave instructions that Dr. Eastwood be commissioned to examine into and report upon the methods adopted in various American States for the control of tuberculosis among herds of cattle in the United States and the prevention of the communication of bovine tuberculosis to man.

The Medical Officer of the Local Government Board—Dr. Arthur Newsholme—also instructed Dr. Eastwood to collect information regarding the means for securing clean milk.

Dr. Eastwood[2] issued a vastly interesting and valuable report on the subject of farmers doing their own tuberculin testing. He says the "....system has excited much interest and not a little hostile criticism. The State Agricultural College met with a storm of opposition from the veterinary interests when it first advocated this policy, but has steadily adhered to it, and believes that the method is thoroughly justified by the results. After I left Madison I had many opportunities of discussing this point, both with men whom I met in Washington at the Tuberculosis Congress and in the course of my visits to several other towns in the Eastern States. Opinions were by no means unanimous. Several men, including prominent veterinary authorities, spoke with approval of the policy adopted in Wisconsin. The adverse criticisms may be summarised as follows:

The objections

"1. The encouragement of the farmers to do the testing themselves was detrimental to the interests of the veterinary profession.

"2. It was undesirable to place tuberculin in the hands of farmers, since it gave them the opportunity for 'doping.'

1. 6th I. C. on T., Vol. 4, pt. 2, p. 761.
2. Dr. Eastwood's Rept. to the Local Government Board on American Methods for the Control and Improvement of the Milk Supply, p. 5. Wyman and Sons, London, or Oliver & Boyd, Edinburgh, or E. Ponsonby, Dublin. Price 6d.

"3. The farmers who performed the test lacked the requisite scientific and clinical knowledge ; the test was often applied to animals which were not in a suitable condition for it, and consequently a large percentage of error crept in, rises of temperature supposed to be diagnostic being frequently obtained when they were really due to some other cause.

"4. These blunders gave the tuberculin test a bad repute and deterred farmers from availing themselves of its advantages when employed by skilled veterinarians. With regard to these four points, I think the following comments are justifiable :

"(1) It would certainly be to the interests of the veterinarians to be employed in making the tests which the farmers now do for themselves. (2) The farmers have to give an account of all the tuberculin they receive ; possibly a few of them try to use it dishonestly, if they think they can escape detection ; but the unscrupulous farmer who wants to 'dope' has never any difficulty in obtaining tuberculin privately from a commercial firm. (3) I have not been able to obtain any precise or published statement as to the magnitude and nature of the farmers' errors ; it would be interesting to know how often this alleged lack of knowledge leads him (*a*) to record an apparently tuberculous reaction in a non-tuberculous animal, or (*b*) to miss a tuberculous reaction in an animal which ought to have given it ; the former mistake, however undesirable, is obviously less detrimental to the suppression of tuberculosis than the latter. (4) I have been unable to find any evidence that the action of the Wisconsin farmers has damaged the repute of the tuberculin test. **Eastwood's views**

"In conclusion, there may possibly be some little element of truth in the adverse criticisms directed against the Wisconsin methods ; precisely how much I do not feel competent to say. It is clear that these criticisms are actuated, to some extent, by a feeling that the Wisconsin authorities are interfering with the legitimate pecuniary interests of the veterinary profession.

"With regard to purely disinterested scientific considerations, there is a complete consensus of opinion that the diagnosis of tuberculosis by the tuberculin test demands both care and skill. In this connection it must be pointed out that the Wisconsin farmers have received instruction in the work at the Agricultural College, and have obtained more practical information about the test than is possessed by many veterinarians in remote country districts of the Western States ; they are not entrusted with the diagnosis, but merely with the inoculations and taking of temperatures ; the diagnosis is made by highly competent authorities at the Experiment Station, after careful scrutiny of the records, and rejection of all charts showing signs of careless work. Apart from the desire not to incur unnecessary expense, an intelligent farmer, with these facilities at his command, has reasonable ground for thinking that he can do the work as well as a good veterinarian, and better than a veterinarian of doubtful reliability. It is also worth noting that in States where the work of tuberculin testing is mainly in the hands of veterinarians, I have not found more tangible evidence of progress towards the eradication of the disease than I have found in Wisconsin."

The following statement by Eastwood[1] is significant: "....of the tests supervised in this way by the Experiment Station during the year 1907-8, 25,719 were performed by the farmers themselves, and 3,099 by veterinarians. The farmers' tests seem to have been carefully recorded, the number which it was found necessary to discard being only 77; the work of the veterinarians, I was informed, exhibited a higher proportion of error."

In our opinion a good deal depends upon the farmer and the opportunities he has had. We have met some farmers of an intelligent, inquiring, and scientific, withal serious and conscientious, turn of mind, to whom we would entrust the testing of our own best cattle with a greater feeling of safety than to many veterinarians we have met, and who have not had much practice in the test.

J. W. Brittlebank assures us that he knows of many farmers he can trust to do their own testing, but they have had opportunities of learning, embraced them, and could put them into practice with skill and judgment.

Mr. John Findlay[2] informs us that the late Mr. John Speir always tested his own stock, "and it would be a great advantage," Findlay continues, "if the farmers were able to deal with their own cattle."

LIMITATIONS OF THE TUBERCULIN TEST.

Negative results

After acknowledging the accuracy of the positive indications of the tuberculin test, Ward[3] inquires: "It remains for us to consider the accuracy of the tuberculin test from the standpoint of the truth of the conclusions drawn from the fact that an animal fails to react. In other words, is the tuberculin test as accurate in its negative conclusions as it is when positive conclusions are drawn from the test? Is the test as searching as we would like to have it? Does it reveal all the tuberculosis in the herd?"

Active and healed lesions

[4]"In using tuberculin certain apparent discrepancies have appeared, which have caused many dairymen to question its value. This is due to the lack of knowledge concerning it. The dairyman does not distinguish between active, healed, or latent tuberculous lesions, and up to a comparatively recent date pathologists have been unable to instruct them in the significance of these technical differences. It is important, however, that the interpretation of

1. Dr. Eastwood's Rept., p. 4.
2. Lecture before the Glasgow and West of Scotland Agricultural Discussion Society. See The Scottish Farmer, Nov. 19th, 1910, p. 1035.
3. California Cultivator, Nov. 11th, 1909.
4. Veranus A. Moore, Cornell University, Ithaca, N.Y., 6th I. C. on T., Vol. 4, pt. 2, p. 919.

the reaction or non-reaction to tuberculin should be clearly understood. The experience of the last few years has called into question certain interpretations and conclusions concerning its accuracy that heretofore were accepted. The findings of Carini, that failure of tuberculin may be expected in about 17 per cent. of cases, and of Lignières, that a tolerance may be established which results in a failure of the tuberculin to give a reaction in certain cases where later *post-mortems* reveal the presence of tuberculous lesions, have been somewhat general when tuberculin has been applied under certain conditions. The phenomenon of the tuberculin reaction has not been satisfactorily elucidated. The explanation offered some ten years ago by Eber, and recently modified by Smith, will, if correct, do much to clarify the confusion regarding the non-reaction to tuberculin in cases where there are healing tuberculous lesions.

Theory of tuberculin reaction

"According to this theory, for the action of tuberculin, 'the tubercle bacilli have induced certain tissue changes, and with them certain new functions of the tissues have been aroused, which are the result of immunisation.' It is the action of the specific product resulting from these changes upon the tuberculin that causes the latter to split off a poisonous substance which causes the elevation of temperature."

Failure to react

Dr. Burton Rogers[1] explains that "....the regular and generally most satisfactory dose is only two cubic centimetres of the diluted standardised tuberculin." This may be "....injected into an animal which has already within its system such a large quantity of natural tuberculin manufactured by the tuberculous germs in immense numbers in its system," without showing the characteristic effect, or, indeed, without any effect at all. "Such animals usually show marked physical and clinical evidence of the disease," hence the reason that clinical examination is always coupled with tuberculin testing for the detection of tuberculosis in bovines.

"Some animals," Rogers continues, "especially young bulls of very strong vigour and vitality, may withstand, up to a certain extent, the physical effects of the disease and its products." This explains why "....animals far gone with disease," as Pope[2] points out, "are often pronounced sound and left in the herd." It is stated that such animals can be detected by clinical examination. On this score Ward[3] says "There are certain cases, however, where it is extremely unlikely that the existence of the disease would be detected in a non-reacting animal. If the disease is not present in the lungs or in those lymphatic glands which are located immediately beneath the skin, and hence readily accessible to the touch, there is little likelihood that the disease would be recognised."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 843.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 577.
3. California Cultivator, Nov. 11th, 1909.

Healing tubercles

Another cause of failure is discussed by Moore.[1] "A study of tuberculous lesions shows that when the process of healing begins, there is formed about the foci a wall of fibrous or fibrous and cellular tissue, which tends, to a certain degree, to separate the lesion from the surrounding tissue and the circulation. The specific product resulting from the tissue changes as stimulated by the tubercle bacilli in the focus is, therefore, largely confined to the diseased area, and cannot act upon the tuberculin if it is subsequently injected. This explains the failure of tuberculin to react in those cases where tubercles are healing. As a small part of the specific product of the tubercle may be disseminated in the circulation or surrounding tissues, and as its elimination may be slow, it is not unlikely that the partial reactions that often occur may be explained on the hypothesis that there still remains enough of the specific substance to liberate poison sufficient to disturb the temperature, but not to cause a characteristic rise. More extended investigations are necessary to determine at what stage in the healing process reaction ceases either in part or completely. It is presumable that a number of conditions contribute to this result. In an experiment with seventeen tuberculous cows, twelve failed after a certain time to react. The *post-mortem* examinations revealed lesions that were small and few in number, and in all cases but one they showed evidence of healing. In four of the five cases that reacted, quite as much reactionary tissue existed about the tuberculous foci as there was about those in the animals that failed to react. In one the disease was very active and general. In other words, the line of demarcation between the lesions in animals that react and those that fail to do so is not always apparent.

Incubation period

"Likewise, the failure of the animals to react during the period of incubation, and the reaction that occurs before lesions are in evidence, bring us to another point that must be recognised and explained on the same basis." This fact is of great importance in exact scientific investigations on tuberculosis, and was referred to by Koch[2] in the following words at the Congress of 1908 :—

"Since the earliest stages of tuberculous infection cannot be recognised with certainty, the source of error arising therefrom is only to be overcome by experimenting on long series of animals. This is especially true of investigations on cattle, as in them tuberculin proves the presence of tuberculosis, not immediately after infection, but only after the lapse of a certain time."

Dinwiddie[3] says: "Usually after intraperitoneal inoculation of sputum[4] into calves a reaction to tuberculin can be obtained in a few weeks. I have seen it within three weeks. This indicates, I think, that an actual infection has taken place, with multiplication

1. 6th I. C. on T., Vol. 4, pt. 2, p. 920.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 646.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 687.
4. Tuberculous sputum.

of tubercle bacilli within the body. After six months we will most commonly obtain no reaction to the tuberculin, indicating that active proliferation has ceased." Ward[1] tells us that "There is a case on record of an experiment made to determine how soon after the injection of tubercle bacilli an animal will react to the test. A reaction occurred within fourteen days after the injection of tubercle bacilli, and upon slaughter no evidence of disease could be found." Marshall[2] reminds us, "It is known that there is a period of incubation for tuberculosis of from eight to fifty days. It is also known that animals will not react to a test during this period."

In review of these shortcomings of the tuberculin test, Moore[3] continues, "Because of these limitations of tuberculin, results have been accepted as failures when the conditions were such that the tuberculin could not cause a reaction, or when the reactions have occurred before the lesions were of sufficient size to be readily found, or were localised in organs and tissues not ordinarily examined."

At the Sixth International Congress, Dr. Rutherford[4] adopted a very pessimistic view regarding the reliability of the tuberculin test. He referred to "....the vagaries of tuberculin, especially on second, third, and fourth tests in the same herds," although on first test it is almost infallible. He had decided to await more and better knowledge from other people's mistakes, but hoped the others would maintain their enterprise and courage.

The following are examples of the vagaries referred to by Dr. Rutherford[5]: The temperature of cow No. 86A in the open-air experiment described on p. 194 showed a distinct rise two hours after injection, but the maximum was not attained until the twenty-fourth hour, while two hours subsequently it was normal.

Calf No. 15B showed the maximum temperature of the reaction two hours after injection. At the eighth hour the temperature was normal. Cow No. 6 attained maximum at the fourth hour, while four others showed the highest temperature at the eighth hour.

"Special attention is directed to No. 4A, which, on being slaughtered on February 19th, 1909, when over two years old, was found badly affected with tuberculosis, although it had never shown any evidence of disease and had been tested four times without reaction, the periods elapsing between the tests being ten, six, and three months respectively.

"This case is both interesting and instructive," Dr. Rutherford continues, "showing, as it does, that an animal, while still retaining externally the appearance of health, may within a comparatively

1. California Cultivator, Nov. 11th, 1909.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 905.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 920.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 870; also p. 883.
5. Rept. of the Veterinary Director General and Live Stock Commissioner. Dept. of Agri., Canada, 1911, pp. 171, 186.

short period become affected to such an extent as to nullify the action of tuberculin. Giving this heifer the benefit of the full period of incubation possible, as stated by our best authorities, namely, fifty days, the disease must, to all appearance, have been contracted not more than five months before the last test, to which, as has been shown, there was no reaction."

Intelligent opposition

Professor Pope[1] was evidently replying to some criticism when he stated that " It is not true that the unintelligent men of this country (U.S.) are the ones opposed to the tuberculin test, as many of these men are doctors, lawyers, bankers, and retired business men."

Explain the limitations

Moore[2] sums up this aspect of a highly important question in the following words : " In the application of tuberculin by veterinarians for eradicating tuberculosis in private herds, it is very important that the limitations of its action be fully appreciated and explained to the owners. This is desirable in order that the necessary precautions may be taken and the expectations of the owner so adjusted that he will not be disappointed by the future results. The tendency of cattle men to believe that when an animal fails to react or ceases to react, if it has previously done so, it is perfectly safe to be placed with sound animals, cannot be overcome without duly acquainting them with the facts.

" If the limitations of tuberculin and the possibilities of infection are taken into account, the conservative method of dealing with bovine tuberculosis, as first recommended by Professor Bang, has great possibilities."

Limitations

" It was said by Regnér,[3] at the International Veterinary Congress held in Budapest in 1905, that tuberculin is an invaluable and indispensable means for the extirpation of tuberculosis, but he who relies exclusively upon it for differentiating between tuberculous and non-tuberculous animals will sooner or later have bitter cause to regret it. Not only tuberculosis permitting of clinical diagnosis, but also cases where tuberculosis is present in a decided but not very high degree, usually not easily to be detected, may with individual animals elude the tuberculin test, and in a relatively short time, under favourable circumstances, commit fearful ravages among the stock found free from reaction. Professor Svenssen, of Stockholm, has also proved, by means of a long series of experiments, that tuberculin is somewhat uncertain for repeated tests upon animals once found to react. These facts render a clinical and bacterioscopic diagnosis imperatively necessary. Suppressive measures must especially be directed against the lung tuberculosis, which is the most important factor of the dissemination of the pest among the cattle stalls."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 583.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 920.
3. Bekämpfung der Tuberkulose der Haustiere. Read at Eighth International Veterinary Congress, Budapest, 1905; quoted by Salmon, B. A. I., Bull. 38, p. 51.

A very serious objection has been urged against tuberculin injection on the score that, although it causes no harm to healthy animals, it stimulates healing or quiescent lesions into increased activity. Bang[1] asks, "Can the reaction produce a worse condition in tuberculous animals than before existed? Hess emphatically states that it can, and on this account he earnestly warns against its application." **Stimulate quiescent lesions**

We have already seen that in human treatment Raw acknowledges that advanced cases of phthisis were certainly aggravated by the excessive reaction caused by large doses of tuberculin (see p. 208). Dr. J. E. Squire[2] observed that the tuberculin test on human beings (by injection) seemed to "cause an increased activity in the tuberculous focus." Newsholme regards this as a possibility, and accordingly deprecates the use of the test on human beings.

We shall deal with this objection to the tuberculin test in the following pages.

Dr. Rutherford[3] mentions the case of six reacting long yearling steers which showed the following temperatures of reaction: 107·6°, 106°, 106°, 108·2°, 106°, 105°.

On slaughter the carcass of only one was condemned. Although tuberculosis was found in four, it was of the slightest character. The sixth was apparently free from disease. The history of the six, Dr. Rutherford says, very strikingly corroborates the theory that the incipient case of tuberculosis gives the highest reaction to tuberculin.

OSCILLATION OF THE TUBERCULOUS PROCESS IN BOVINES.

The Significance of Dormant Encapsulated Lesions.

[4]"An animal may fail to react to the test owing to the temporary arrest of the disease. In cattle as in man there is a very strong tendency toward recovery from infection with disease. Nature tends to enclose diseased areas within a wall of fibrous tissue which does, temporarily at least, check the progress of the disease. This healed-up area may, however, harbour live tubercle bacilli in the interior. Slaughter of animals with arrested tuberculosis has permitted us to demonstrate live tubercle bacilli in the partially healed spot, even though the animal did not react to the test. Thus a cow may react to-day as the result of active progressive tuberculosis, and later may not react because Nature has temporarily overcome the disease. The progress of the disease may remain thus arrested for years and then again break out in progressive form, when it will cause a reaction to the test. **Healed lesions do not react**

"It has long been recognised that one tuberculin test with removal

1. Quoted by Salmon and Smith, B. A. I., Circular No. 70, p. 15.
2. Quoted by Newsholme, The Prevention of Tuberculosis, p. 313.
3. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 170.
4. Professor A. R. Ward, California Cultivator, Nov. 11th, 1909.

of reacting animals, followed by thorough disinfection of the stable, will not check the progress of the disease in the herd. This circumstance was formerly attributed to poor disinfection or the accidental introduction of infection through gross carelessness. This all might occur, but there certainly have been cases, conducted under the supervision of experts, in which these errors did not occur, and under such circumstances the blame is laid upon the non-reacting tubercular cow in which the progress of the disease has been temporarily checked. Moore has made a special study of the behaviour to successive applications of the tuberculin test to the animals which did not react to the first application of the test applied to a badly infected herd."

A certain ". . . . herd of 491 animals showed only 96 that did not react to the test. That is, 80 per cent. of the animals did react. These non-reacting animals were placed by themselves and thoroughly isolated from the possibility of infection. They were tested three months after the first test and every six months thereafter. In each case the reacting animals were promptly removed and the stable disinfected.

"The results are presented in the following table :—

Date.		No. Tested.	No. Reacted.	No. not Reacting.	Per cent. Reacting.
1904	July ..	96	31	65	32·2
1905	January	65	8	57	12·3
1905	July ..	57	15	42	26·3
1906	January	42	15	27	35·7
1906	July ..	27	3	24	11·1
1907	January	24	2	22	8·3
1907	July ..	22	1	21	4·5
1908	January	21	1	20	4·7
1908	August	20	1	19	5·0

"The conditions were such in this experiment that we must regard the appearance of reaction among the animals in this herd as due in each case to renewed activity of the disease in an infected area which had become temporarily healed previous to the very first test. The *post-mortem* examination of such of the animals as were killed bore out this conclusion. It is interesting to note that tuberculin tests of these reacting animals repeated after an interval of three months showed that fully 25 per cent. failed to react. Here is evidence of oscillation between an active and an arrested condition of the disease as indicated by the tuberculin test. We cannot depend upon the tuberculin test to indicate the absence of tuberculosis in an animal. The fact has important bearing upon the matter of the purchase of animals subject to the tuberculin test with the idea of putting them in a clean herd.

Negative tuberculin tests unreliable

"In practice, by purchasing animals from infected herds, we are bound to pick up cases of non-reacting, arrested cases of tuberculosis. These are temporarily harmless, but we must keep a vigilant guard to prevent their infecting the herd after they have further succumbed to the inroads of the disease. The only way to do this is to apply the tuberculin test to the herd every six months in any herd supposed to be free from the disease. . . . . It would be far better to purchase animals only from herds entirely free from the disease.

"Moore[1] gives some interesting figures bearing on this subject of the purchase of animals subject to the passing of the tuberculin test. Ninety-two cows were purchased on the test in a district where the disease was prevalent. They were kept by themselves and tested every six months afterwards.

Purchase on tuberculin test

Date.		No. Tested.	No. Reacted.	No. not Reacting.	Per cent. Reacting.
1907	January	92	0	92	0
1907	August	92	3	89	3·3
1908	January	89	24	65	26·9
1908	August	65	4	61	6·2

"Moore gives other instances showing the value of purchasing cows by the test from a tuberculosis-free herd as compared with the results of cows from infected herds.

"Tuberculosis can be kept in check in dairies by the testing of every animal purchased and by testing the whole herd every six months. This is being done in the certified herds in the San Francisco Bay region. It is not uncommon, though, to have the percentage of reacting animals go as high as seven. Any relaxation of vigilance, as manifested by the semi-annual testing, would speedily result in the serious reinfection of the herd. The reactors must be detected early and removed before they become centres of infection.

Remove reactors promptly

"It seems safe to conclude that there is little chance of success in separating a herd of tuberculous and non-tuberculous animals by means of the tuberculin test, especially if the herd is badly infected. The Bang method offers in such a case the only practicable method of getting out of the trouble."

Moore[2] states that "This oscillating of the morbid process between an active and arrested condition is an important factor in considering the future of the supposed healthy animals and in interpreting the tuberculin reaction."

Oscillation of tuberculous process

Professor Pope[3] says: "I know of nothing that has so much hampered the fight against bovine tuberculosis as the almost universal distrust of the tuberculin test which prevails amongst farmers. No doubt this is due partly to the natural conservatism of the farmer, partly to the influence exerted upon him by supposed authorities, and partly to the fact that the test affords the means of attack upon his herds. But after due allowance is made for these factors, there still remains justifiable grounds for the farmers' opposition. Those

Farmers distrust tuberculin

1. Quoted by Ward, California Cultivator, Nov. 11th, 1909.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 922.
3. 6th I. C. on T., Vol. 4, pt. 2, pp. 577-8.

who applied the test in the past have made many blunders, and to-day the mistakes are so many and so widely known that the veterinarians, or those who claim this title, have much to answer for. The custom is to apply the test and, in case of reaction, to test its correctness by careful *post-mortem* examination. This puts the one who applies the test on the defensive, and in case disease is not found, the farmer is filled with anger and contempt, even though he is paid full market value for the animal which he believes to have been mistakenly condemned. A mistake such as occurred recently in Minnesota, where four out of eleven animals slaughtered were pronounced perfectly healthy, will prejudice an entire community against the test."

Errors of this kind, and the still more serious one of the failure to detect the animals in the advanced stages, previously referred to (p. 227), are "To the breeder of fine stock....grave indeed. They may result in the useless sacrifice of a healthy animal and the retention in the herd of an animal the presence of which will make such sacrifice worse than useless. My conviction is," continues Pope, "that unless such mistakes can be avoided, the opposition to the extensive use of the test will be overwhelming—a condition of affairs which would be most unfortunate." In reference to the failure to detect lesions in reacting animals, discussed by Pope, it is interesting to note the distinction drawn by Professor Arloing[1] between those which can be detected by visual inspection (macroscopical lesions) and microscopical lesions which can be detected only by animal inoculation. When *post-mortem* examination of a reacting animal fails to reveal visible lesions, Heymans[2] concludes that it is a clear indication of the uncertainty, not of the tuberculin test, but of the *post-mortem* examination.

Mr. James Kirby's experience

Mr. James Kirby, a prominent practical authority in our own country, tells us of a somewhat similar experience as referred to by Pope. "When residing at Ashford, Kent," says Kirby,[3] "I was milking 120 cows, and being interested in tuberculosis, decided to have 80 tested, so communicated with Professor Sir John M'Fadyean, of the Veterinary College, London, in response to which he sent down Professor Hobday to test the animals. I shall not forget his words when he saw them, his remark being 'What a nice lot of animals. I should not think you have a tuberculous one among them.' Anyhow, the test worked out as follows :—

41	tuberculous.
7	doubtful.
29	free.
77	total injected.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 772.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 522.
3. Private communication, dated Jan. 10th, 1910.

"Now, all these animals were, in course of a few months, fatted and sold to local butchers, and on examination, in several that had reacted, no trace of tuberculous lesions could be found. On the other hand, several that had shown free, on being examined, proved tuberculous. This latter might be answered by the fact that it was possible they could have been infected after the test; but not so the former, and my only explanation is that the test is not reliable. It is now, I believe, generally admitted that animals in an advanced stage of tuberculosis often refuse to react to the test, but these animals could not be classed as such, as is evidenced by Professor Hobday's remark quoted above." Mr. Kirby also quotes to us the opinion of Dr. Voelcker,[1] at the Society of Arts on December 16th, 1908, *re* tuberculin test—"From my personal experience, I must say that I do not believe in it"—and the report of the Chief Veterinary Inspector of U.S.A., issued about the beginning of 1909, to the effect that the inspector found a fallacy approaching 5 per cent. in his test of over 400,000 animals.[2]

Regarding the proportion of animals which may be tubercular, although failing to react on the first test, Moore[3] says: "The existing conditions relative to the duration and extent of the infection are important factors in considering the probable outcome of non-reacting animals in the original herd. In certain herds, where the Bang method has been applied under my personal observation, the results have been quite different respecting the original non-reacting animals. In one case where there were 17 reacting and 13 sound individuals, only one of the 13 subsequently reacted, although tested semi-annually for four years. In other herds a much larger percentage of the supposed sound animals were victims of this insidious infection."

DR. MED. BOLLE
Berlin.

Dr. Bolle[4] reminds us that Pusch, in his Kindermilch-produktion (production of milk for infants), emphasises the fact that there are animals in which the reaction is at one time positive, and again, negative. Bolle confirms this view from his own experience with 304 cows examined in his dairies between January 1st, 1907, and March 1st, 1909. These cows were only admitted to the dairy herd on a negative result of the tuberculin test. Among the 304 non-reactors 75 subsequently reacted, and among these 75 seventeen showed fluctuations to

1. Jour. of the Roy. Soc. of Arts, Dec. 18th, 1908, p. 90.
2. Probably Mr. Kirby refers to the figures given on p. 249, which, however, show an error of less than 2 per cent.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 921.
4. Berliner klin. Woch., 1910, No. 26.

repeated tests. In the following table ten of these records are shown :—

Herd No.	Breed.	Date.	Dose.	Result.
75	Simmenthaler	4/3/05	0·5	negative
		20/7/05	0·5	do.
		30/3/06	0·5	do.
		24/11/07	0·5	positive
		19/3/08	0·5	negative
		12/7/08	2·0	do.
		13/11/09	1·0	do.
83	Simmenthaler	26/7/04	0·5	do.
		29/8/06	0·5	positive
		25/11/07	0·5	negative
		19/3/08	0·5	positive
		2/4/08	0·5	negative
		17/8/08	2·0	do.
89	Simmenthaler	27/7/04	0·5	do.
		4/3/05	0·5	do.
		20/7/05	0·5	do.
		30/3/06	0·5	do.
		24/11/07	0·5	positive
		18/3/08	0·5	negative
		17/8/08	2·0	positive
215	Landrasse	7/4/08	0·5	negative
		17/8/08	2·0	do.
		6/11/09	1·0	positive
		15/2/10	1·0	negative
218	Landrasse	7/4/08	0·5	do.
		17/8/08	2·0	do.
		13/11/09	1·0	positive
		15/2/10	1·0	negative
221	Ostpreusse	30/7/08	2·0	do.
		14/8/08	2·0	do.
		30/10/09	1·0	positive
		15/2/10	1·0	negative
226	Ostpreusse	30/7/08	2·0	do.
		14/8/08	2·0	do.
		13/11/09	1·0	positive
		15/2/10	1·0	negative
242	Ostpriegnitz	21/8/08	2·0	do.
		16/11/09	1·0	positive
		15/2/10	1·0	negative
256	Ostpriegnitz	21/8/08	2·0	do.
		12/11/09	1·0	positive
		15/2/10	1·0	negative
282	Weser-Marsch	1/12/08	2·0	do.
		16/11/09	1·0	positive
		15/2/10	1·0	negative

In reference to the apparently small doses of tuberculin employed, we may explain that the vaccine used by Bolle was that supplied by the German Government, and is several times the strength of the ordinary tuberculin as used in this country, so that even 0·5 c.c. is quite a sufficient dose.

Dr. A. Carini,[1] Chief of the Vaccine Department of the Swiss Serum and Vaccination Institute of Berne, also records a high percentage of failures of the tuberculin test. His data refer to 361 calves, steers, and heifers used for production of lymph. Before being used for this purpose the animals were tested with tuberculin and subjected to a careful veterinary examination, only those animals which met the most stringent demands being accepted. The tuberculin used was prepared in the Swiss Serum and Vaccination Institute. It is standardised to the basis that 0·3 c.c. injected subcutaneously into tuberculous guinea-pigs always proves fatal. The injection of the calves and observations of temperatures were carried out by Professor Dr. Hess or his assistants. The autopsies of the calves, all of which were slaughtered after withdrawal of the serum, were performed by Meat Inspector Räber, of the Berne Abattoir. Carini observes that every effort was made to eliminate error, and although no histological or microscopical methods were employed in the *post-mortem* work, 17 per cent. of the calves were found tuberculous, although shortly before no signs of disease, tubercular or otherwise, could be discovered in the living animals.

CAUSES OF FAILURE OF THE TUBERCULIN TEST.

The causes of failure discussed in the foregoing may be regarded as physiological. The difficulty of detection during the period of incubation apparently cannot be obviated in the present state of our knowledge except by quarantine and re-testing. Regarding the remaining causes due to tolerance, arising from latent and healed lesions, cessation of active proliferation, advanced stages of the disease, high vitality, as found, for instance, in young bulls, microscopical lesions not visible to the eye, and doubtful reaction, we have good reason to believe from some unpublished data collected by J. W. Brittlebank, Veterinary Officer for the City of Manchester, during the last ten years of earnest work, that an increased dose of fully potent tuberculin, coupled with precise and critical observation, will secure a positive result. Brittlebank tells us that with the single reservation of those in the incubation period he has yet to find the tuberculous animal that will not react. Moreover, during ten years of active testing, he has only failed to find lesions in one single animal among those that reacted. **Unavoidable cause**

On the other hand, Dr. C. Bolle,[2] of Berlin, made careful observations on the tuberculin testing of 304 cows, and, acting on the advice of Eber and Luders, used large doses to eliminate the uncertainty of the tuberculin test. Bolle acknowledges that the plan was unsuccessful in this respect.

We are thus led to the consideration of another set of preventable **Disinfection**

1. Archiv für Wiss. und Prakt. Tierheilkunde, Bd. 32, H. 6, p. 562.
2. Berliner klin. Woch., 1910, No. 26. August Hirschwald, Berlin.

causes of failure in tuberculin testing. Pope[1] points out that unless disinfection after the removal of reacting animals "....is thoroughly carried out, it is quite useless to clean up a herd."

Segregation

Jobson[2] defines the following additional causes; the failure to at once separate and place the reacting animals in quarantine,[3] neglect of systematic application of the test at proper intervals, and to maintain the animals under normal conditions for a day or two preceding and until the completion of the test. Cattle exposed to extreme cold previous to taking their initial temperatures, and kept in a warm stable during the remainder of the test, are not likely to give accurate results. Their initial temperatures in some cases range from 98° Fah. to 100° Fah. Under the same conditions, were no tuberculin used, there would be a perfect natural reaction following the low temperatures of the preceding day. Those opposed to the tuberculin test point to the fact that cattle tested prior to purchase have, on a re-test, reacted. Such cattle have not been honestly tested—for there are a few unscrupulous men in the veterinary as well as in other professions. Unless absolutely sure that the herd from which the cattle are purchased is free from tuberculosis, it is advisable to quarantine them for two months or so, and re-test them before they are mixed with the herd.

Careless testing

Dishonesty

Testing young calves

"The temperatures of very young calves are frequently erratic," Jobson continues, "and it is much the safer plan, when suspected of having tuberculosis, to hold them in quarantine until they are at least six months old, previous to testing."

[4]"In purchasing an animal on the tuberculin test, there is the danger that the animal may pass the test and later develop sufficient disease to cause reaction to the test. There is a period shortly after the germs of tuberculosis have entered the system during which the animal will not react to the tuberculin test. In such a case the test is no protection against the introduction of the disease."

Quality of tuberculin

Regarding impotent tuberculin, Mohler and Washburn[5] say that "Congress has recently granted power to the Department of Agriculture to examine and report upon the results obtained from the use of various kinds of tuberculin sold in this country (U.S.A.). This power of keeping the public informed upon the value of such an important biological product as tuberculin came none too soon, for worthless tuberculin has been found on the market, and there can be no question that many inconsistent results—results which were embarrassing to the testers and caused dissatisfaction among the stockmen—can be explained by the inertness of certain of these products."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 767.
3. Professor Sir John M'Fadyean (Jour. R. A. S. E., 1910, p. 39) says, "If this is not possible any hope of eradicating the disease must be abandoned."
4. Professor A. R. Ward, California Cultivator, Nov. 11th, 1909.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 637.

Unfortunately, there are veterinarians who do not know how to perform or, more frequently, interpret the results of the test. Shortly before penning these lines we met with a case in which a veterinary surgeon had reported one reactor among five cows tested. Without any doubt of the correctness of his diagnosis, the figures were shown to a highly-experienced and qualified veterinarian, who immediately pointed out that instead of only one reactor there was only one that had *not* reacted. Incompetency

Having received an injection of tuberculin, an animal, even if tuberculous, will not react to another ordinary dose until the effects of the first injection have worn off.[1] This process has been used dishonestly to prevent reaction in diseased animals when offered for sale.[2] This applies only to the subcutaneous method, however. Professor Vallée's discovery (see p. 261) enables one to surmount this difficulty if quarantine for two months or so and re-testing are impracticable. Moreover, evidence is accumulating to the defeat of "fortifying." Carini[3] tells us that in rare cases animals have been known to react five or six hours after injection, whilst in other instances the reaction has been delayed for 24, or even 36, hours. According to the usual procedure of observing, such cases as the above would be entirely missed. Early reaction appears to be a feature in the case of animals which have been injected a short time previously. The late Professor W. Owen Williams[4] assured us that he had several times defeated the "doping" procedure by early observation of temperature. "Doping" or "Fortifying"

Professor Sir John M'Fadyean, as we have seen, points out this precaution (see p. 224).

In view of Professor Vallée's announcement, a few years ago, that animals might not react to a tuberculin test if they had recently been tested before, Dr. Rutherford[5] made 161 tests in such a way as to ensure the detection of any abnormally early reaction. One hundred and nineteen of these were reactors, and in twenty-one the period between the tests was less than three months. Seven cases of early reaction were observed, the highest temperature being attained in from two to eight hours; but none of these early reactions occurred in the twenty-one cases in which the preceding test had been made less than three months before. Most occurred in animals which had not been tested for nearly a year.

On the advice of Eber-Luders, Dr. Bolle[6] adds carbolic acid

1. This fact has been demonstrated, as Carini points out (Archiv für Wiss. und Prakt. Tierheilkunde, Bd. 32, H. 6, p. 562), by Witt, Berl. Tierarztl. Wochenschr., 1904; Bartels, Munch. med. Wochenschr, 1902; Vallée, Ann. Pasteur, 1904.
2. And even openly gloried in.
3. Archiv für Wiss. und Prakt. Tierheilkunde, Bd. 32, H. 6, p. 562.
4. Private communication.
5. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 171.
6. Private communication, dated Jan. 17th, 1911.

to his tuberculin used for injection of new cows which may be "fortified." Using the strong tuberculin already mentioned (see p. 242), the following mixture is used :—

Strong tuberculin, 2 c.c.

0·5 per cent. solution of carbolic acid in water, 3-3½ c.c.

Following an interesting lecture by Professor G. E. Day[1] at a meeting of Ontario farmers, the professor stated that although a "fortified" animal might not react it would almost invariably tremble. "If an animal does that after injection, I would condemn him," the professor continued, "just the same as if he showed a rising temperature."

RELIABILITY OF THE TUBERCULIN TEST.

We have admired the clear and fair exposition under this heading given by John M. Deering,[2] and feel we cannot do better than quote the words of this able American authority.

Best agent but not infallible

"Do we believe in the tuberculin test? Yes. Is tuberculin infallible? No; neither is anything else made by man. We believe it to be the best agency known to human science to diagnose a case of tuberculosis. Tuberculous cattle are not all sick. We test cattle in Maine to get rid of the diseased ones, for the dairymen do not want them in their herds. They know by actual experience that the longer

Tuberculosis unprofitable

tuberculosis remains in a herd, the more of it there will be, and that, as a matter of dollars and cents, it is not profitable.

"At the present time there is but little controversy in Maine about destroying animals that have reacted to the tuberculin test.

Lesions not found

In practice it has been found that of 100 condemned cattle, there is from 4 per cent. to 5 per cent. that upon our *post-mortem* examinations will not show evidence of the disease. Another 10 per cent. to 15 per cent. show only slight evidence of the trouble. The remainder, or 80 per cent., show such conclusive evidence that the most sceptical are satisfied and glad to be rid of the animals. It is with the 5 per cent. of animals that fail to show evidence of the disease on *post-mortem* examination that the whole fabric of controversy rests. Many farmers, knowing little of the theory of the tuberculin test, and practically nothing of tuberculosis in cattle, were apt at first thought to say that a mistake had been made, and in some cases designing persons were more than willing to encourage and foster this belief in their minds.

"Ten years ago it was a more common belief than it is to-day. It is now more generally understood that if there is the slightest disease about the animal, it will react under tuberculin. There must be a time when the animal passes from a sound to an unsound condition. Not that it passes directly from a healthy to an utterly diseased one;

1. See The Farmers' Gazette, July 22nd, 1911, p. 636.
2. John M. Deering, Saco, Maine, 6th I. C. on T., Vol. 4, pt. 2, p. 914.

but just as seed sown in the ground germinates and grows. As daylight passes, who can say just when night begins? The seed of tuberculosis is sown and tuberculin will show it up, whether much or little, and does not need the full-grown plant of luxuriant disease. The germinating seed answers every purpose, but the change may not be distinguishable to the eye; yet who can say (if allowed to know in advance) how soon, or when, this seed can grow to the tree of disease that envelops the whole carcass?

"As my work and experience have increased, so has my belief that theory and practice show the truth about tuberculin—that it will demonstrate the presence of tuberculosis, whether much or whether little, with wonderful precision. We used to have some controversy over the cases that only showed slight evidences of the trouble, but we taught the farmers that if they used tuberculin they must submit to its results; that it could not nor would not reveal all cases; but if the animal reacted, it was surely tuberculous, and while a small percentage might show the trouble only slightly, no man could tell what ones they were by the test or the reactions, and that if we undertook to leave any, we were as liable to leave the worst one as any other.

"Very many animals that have shown physical perfection during life were proved to be badly diseased when destroyed, and I have grown to the belief, more every day, that its physical condition is no evidence of its actual condition."

In fighting tuberculosis in the State of Maine, Deering[1] tells us they are working by four methods: First, by the tuberculin test, "....not because we love it," he says, "but because it is the only way at present by which we can clean up a tuberculous herd." Tuberculin test the only way

The remaining methods are sanitation, disinfection of premises after removal of infected animals, and bovovaccine (see p. 386).

"Tuberculin," says Reynolds,[2] "is firmly established as a reasonably accurate diagnostic." Newsholme[3] confirms this view. Reasonably accurate diagnostic

Noack[4] says: "....tuberculin is the only medium by which we may eliminate tuberculosis from cattle, and is also recognised, even by laymen, as the only safe agent to detect and determine the condition as to the prevalence of disease in a dairy herd, which is evident from the resolutions passed by the International Congress of Dairymen, October, 1905, at Paris."

Referring to the fine-looking cows showing no clinical symptoms of tuberculosis, but which, nevertheless, proved in Schroeder's experiments on stable infection to be the most active disseminators of the disease, Mohler and Washburn[5] say, "Cattle of this kind show that

1. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 944.
3. The Prevention of Tuberculosis, p. 313.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 993.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 631.

it is impossible to eradicate tuberculosis from a herd without the use of tuberculin."

Jobson is clear that the use of tuberculin affords the only means for detection of bovine tuberculosis before the advanced stage.

Delépine[1] states that the use of tuberculin affords "....the only reliable test for the diagnosis of early tuberculosis."

Reliability fully established

The reliability of the tuberculin test, Mohler[2] tells us, "has now been fully established, and its use upon cattle as a diagnostic agent has become quite universal."

Newsholme[3] states that "It appears....that the reaction when it occurs is trustworthy, but that a negative result is less reliable."

Schroeder[4] concludes that "After years of observation the tuberculin test has been found to be a more nearly infallible means for diagnosing tuberculosis than any we have for diagnosing other diseases of men and animals."[5]

According to Professor Arloing,[6] Lyons, France, "The tuberculin test is absolutely reliable in all reacting cases, and animals which react should be considered as being affected with tuberculosis."

Carini[7] agrees that most observers concur in this view.

Calmette[8] maintains that tuberculin "....is indisputably the best agent that we possess for revealing the existence of latent tuberculous lesions. No other laboratory or clinical method of examination gives more accurate or more prompt diagnostic information."

"I have absolute confidence in tuberculin," says Wladimiroff,[9] "and in my experience, I have found that by careful usage it renders very valuable service.....I have made no mistakes in the use of tuberculin except where the disease was very far advanced."

Mohler[10] confirms Law,[11] who states that "In skilled hands the tuberculin test will show at least nine-tenths of all cases of tuberculosis when other methods of diagnosis will not detect one-tenth."

British Royal Commission

The experts of the last British Royal Commission on Tuberculosis,[12] in discussing their experiments, state that "A considerable amount of information has in this way been obtained as to the value of the tuberculin test as a means for detecting the existence of tuberculosis in bovine and other animals. This matter will be dealt with in detail in a future report. For the present it will be sufficient to

1. 38th Ann. Rept. L. G. B., p. 410.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 634.
3. The Prevention of Tuberculosis, p. 313.
4. B. A. I., Circular 118, p. 19.
5. We are of opinion that mallein for the detection of latent glanders is quite as reliable.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 772.
7. Archiv für Wiss. und Prakt. Tierheilkunde, Bd. 32, H. 6, p. 563.
8. 6th I. C. on T., Special Vol., p. 77.
9. 6th I. C. on T., Vol. 4, pt. 2, p. 882.
10. P. H. and M. H. S., Bull. 56, p. 512.
11. Text Book of Veterinary Medicine, Vol. 4, p. 465
12. Second Interim Rept., p. 43.

express the opinion that the test is one of great value when properly carried out."

A. D. Melvin, D.V.S.,[1] Chief of the United States Bureau of Animal Industry, tells us that "Out of 24,784 reacting animals slaughtered, lesions of tuberculosis were found in 24,387, a percentage of 98·39. . . . in at least one State the testing was not done in a careful and reliable manner. If we discard the returns from this State the proportion of cases in which the tuberculin reaction was confirmed by *post-mortem* is raised to 98·81 per cent. It is possible, too, that in some of the negative cases tuberculosis was really present, but the lesions were so slight as to escape detection on *post-mortem* examination by ordinary methods. Surely these figures, representing the work of scores of individuals in all parts of the United States over a period of fifteen years, bear strong testimony to the marvellous accuracy of the tuberculin test. Further evidence on this point is afforded by the slaughter, during the past year or two, in or near the city of Washington, of 126 cattle which had reacted to the test when applied by Bureau veterinarians, with only one failure to find lesions of tuberculosis on *post-mortem* examination, the percentage of accuracy being 99·21. Properly prepared tuberculin applied by competent persons is thus shown to be a wonderfully reliable agent for diagnosing tuberculosis. In cases where the test appears to give unsatisfactory results, this is usually due to the use of a poor quality of tuberculin or to ignorance or carelessness in applying it."

Marvellous accuracy of tuberculin test

Salmon[2] quotes the carefully compiled statistics published by Voges[3] in 1897, in which it was shown that of 7,327 animals tested, and of which the accuracy of the tests was determined by *post-mortem* examinations, there were but 204 errors of diagnosis, or 2·78 per cent.

Pearson[4] states that in the work of the State Live Stock Board of Pennsylvania *post-mortem* examinations were made on about 4,400 cattle which had reacted to the tuberculin test, and that among all these animals there were but eight in which no lesions of tuberculosis were found. He adds with reference to these that we are not justified in saying that tubercular lesions did not exist, for the reason that every portion of the carcass could not be examined; but it could only be said that they were not found.

In connection with tuberculosis of the udder, we have already considered the difficulty of finding tuberculous lesions on *post-mortem* examination. The same principles hold for any other part of the body, and it is, therefore, far from surprising that in a few cases the lesions cannot be found.

As Carini[5] points out, the lesions may be located in the interior of

1. 6th I. C. on T., Vol. 4, pt. 2, p. 504.
2. B. A. I., Bull. 38, p. 49.
3. Der Kampf gegen die Tuberkulose des Rindviehs, Jena, 1897, pp. 14, 15.
4. Pennsylvania Dept. of Agri., Bull. 75, 1901.
5. Archiv für Wiss. und Prakt. Tierheilkunde, Bd. 32, H. 6, p. 563.

bones or joints ; or, as Russell and Hastings[1] state, in the brain, bone marrow, glands of the muscles, etc. "It is usually impossible to make a thorough examination of the entire carcass, especially where the examination must be hurried and superficial, as that done by regular meat inspectors, whose duty it is not to determine whether the animal is actually diseased or not, but whether the meat should be condemned as unwholesome for food."

Dr. Rutherford[2] directs special attention to a case of a reacting animal in which the only lesion found *post-mortem* was in a popliteal gland. This, he says, would scarcely have been detected in the ordinary abattoir inspection, and might easily have been missed in even a reasonably thorough *post-mortem* examination.

S. Arloing[3] maintains that tuberculous infection is not always characterised by changes discoverable by touch and the unaided eye. There are cases, he says, in which tuberculous infection has not produced any tissue lesions, and may, perhaps, never produce any. In collaboration with Dr. Lucien Thevenot he has studied the viscera and lymphatic ganglia of a great number of laboratory test animals, young bovines and goats, inoculated with weakened tubercle bacilli of varying degrees of virulence. In four-fifths of the cases, only microscopic changes resulted.

When the bacilli were injected under the skin, temporary swelling resulted, but after this had subsided it was generally impossible to find lesions with the help of the microscope. After intravenous injection (into the blood stream) very small lesions were found—alterations in the cells—such that to decide on their reality it was necessary to compare with numerous sections of organs of healthy animals.

Histological dissimulation of tuberculosis

When the animals were infected by swallowing the changes were still more difficult to perceive. In all cases the external appearance of the organs was normal, and could not by any chance be detected by an ordinary *post-mortem* examination. All the animals reacted to tuberculin.

These results are strictly in accordance with the findings of other observers we have referred to elsewhere, and serve well to impress the importance of realising that tuberculous infection varies from a trifling and possibly temporary alteration to others of acute intensity and rapid course. As Salmon[4] reminds us, "The reaction to tuberculin is no indication of the extent of the disease in the reacting animal, and there is frequently a greater reaction in an animal with slight lesions than in another in which the disease is very much more

1. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 21.
2. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 186.
3. Jour. de Medecine Veterinaire et de Zootechnic, Tome 60, Feb. 28th, 1909, p. 65.
4. B. A. I., Bull. 38, p. 52.

advanced." One can thus appreciate on the one hand the enthusiastic esteem in which the tuberculin test is held by pathologists as a critically searching method, and on the other hand the prudent doubts arising in the minds of conservative veterinarians regarding the desirability of compulsory slaughter of animals on the result of the test alone.

"It will be a difficult matter," says Marshall,[1] "to convince the masses of the fully-established harmlessness and usefulness of tuberculin, so long as some agricultural and daily papers continue to malign its use.

"It is hoped that these agencies will soon see the facts in their true light and recommend the truthfulness and good qualities of tuberculin, rather than continually to condemn it and herald the mistakes and blunders that are made by those who are incompetent to use it." (See also the remarks of Governor Hoard on this point, p. 359.)

"The necessity for some specific reaction to detect tuberculous infection," says Moore,[2] "....has caused the value of tuberculin to be appreciated and employed by a steadily increasing number of cattle owners."

Regarding the tuberculin testing at the request of cattle owners in the State of Pennsylvania, Louis A Klein, V.M.D.,[3] Harrisburg, Pa., tells us that "At no time since the beginning of this work have the resources of the Live Stock Sanitary Board been sufficient to meet the demands of those who desired to co-operate with the State in the repression of tuberculosis in their herds." The number of applications in the State of Pennsylvania were in 1908 more than the available funds would pay for.[4]

Is the test always correct?—Not absolutely so, for a number of reasons.

Russell and Hastings[5] state, "When applied with judgment and care it is correct in at least 95 per cent. of the cases."

The International Commission on the Control of Bovine Tuberculosis,[6] "....recognising after careful study that the tuberculin test is the fundamental factor in any policy having for its object the control of bovine tuberculosis, decided that a pronouncement to that effect should properly occupy a foremost place." The Committee on disposition of tuberculous animals (part of the same Commission) state that[7] all recognised authorities are agreed that the tuberculin test is a very important step in the eradication of tuberculosis.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 904.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 919.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 548.
4. See Reynolds, 6th I. C. on T., Vol. 4, pt. 2, p. 933.
5. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 21.
6. Rept. Int. Com. on C. of B. T., p. 8.
7. Rept. Int. Com. on C. of B. T., p. 25.

A dozen years ago Professor (now Sir) John M'Fadyean[1] expressed his "....most implicit faith in tuberculin as a test for tuberculosis when it is used on animals standing in their own premises and undisturbed." The members of the Royal Commission, in their Report of 1898, entirely accepted these conclusions and entertained no doubt as to the value of tuberculin, provided the test was applied by a competent veterinary surgeon, and that the tuberculin was of trustworthy quality. Professor Sir John M'Fadyean[2] confirms this opinion to-day, and adds that [3]"....the owner who refuses to accept the test as trustworthy shuts the door against all efforts to give his herd a clean bill of health." When the subcutaneous test is employed in conjunction with the newer methods, especially the ophthalmo test (see p. 261), it is probably no exaggeration to say, the professor continues, "....that one can now use the test in such a way as to make it almost impossible for a case of tuberculosis to escape detection."

Stimulation of quiescent lesions

We now arrive at the consideration of the question whether tuberculin stimulates tuberculous lesions to increased activity, or, expressed in simple manner, whether it makes the disease worse when it happens to be present?

In discussing Hess's opinion on the matter, Bang[4] admitted that, in his earlier acquaintance with the subject, he had some similar suspicions, but that further experience had failed to verify them, so that he believed stimulation occurred only in cases of advanced tuberculosis. In the herd of his own experimental farm, and in a number of other herds, annual injections of tuberculin were carried out, yet the disease appeared to be stationary among the reacting animals.

Neither were any untoward results observed by the veterinarians among whom Professor Bang inquired. No more animals broke down with tuberculosis among the tested herds than would be expected in the ordinary way had no testing been done. Moreover, beasts were pronounced healthy by the butchers although the animals had reacted, in one case more than twenty months previously.

Bang maintained that the constantly increasing demand of Danish farmers for tuberculin testing was a proof that the testing was not followed by bad results.

Salmon and Smith[5] also quote the testimony of Paige after testing the herd of the Massachusetts Agricultural College. The use of tuberculin, said Paige, "....is not followed by any ill effects of a serious or permanent nature."

"Conn, who made a special study of the attitude of European science towards tuberculosis in cattle, pointed out that 'Even those

1. Quoted by Delépine, The Lancet, Aug. 24th, 1901.
2. Jour. R. A. S. E,, 1901, p. 38.
3. Jour. R. A. S. E., 1910, p. 39.
4. Quoted by Salmon and Smith, B. A. I., Circular No. 70, p. 15, 1904.
5. B. A. I., Circular No. 70, p. 17.

who have been most pronounced in the claim that there is injury thus resulting from tuberculin have, little by little, modified their claim, until....they say either that the injury which they formerly claimed does not occur, or that the stimulus of the disease is so slight that it should be absolutely neglected, in view of the great value which may arise from the use of tuberculin.'"

Favourable rather than dangerous

Salmon[1] collected the opinions of many experts showing that "Tuberculin has little or no effect upon healthy cattle," and that its action upon tuberculous cattle is not serious. "It is doubtful," Salmon continues "if tuberculin in this dose (diagnostic dose) ever aggravates the tuberculous process in cattle, and there is some evidence that it may have a favourable effect." Heymans confirms this latter opinion (see p. 401).

More recently, Bang[2] has given further confirmation of his view expressed above. The following questions and answers were given at the close of an address before the New York State Veterinary College :—

Q. "Do you believe that tuberculin will develop tuberculosis or any bad effects in healthy cows ?"

A. "No. Absolutely impossible."

Q. "Will tuberculin aggravate the disease in affected cows ?"

A. "The immediate effects are fever, smaller quantities of milk, and sometimes diarrhœa ; but there are no lasting effects."

Q. "In an incipient case, will the test aggravate or make worse the disease ?"

A. "I have thought that the disease was aggravated, but now believe that the aggravation was simply accidental and due to other causes."

The State Board of Health of Maine,[3] U.S.A., affirm that when tuberculin is "Applied by a properly instructed person, it is doubtful whether any real injury results, to even the tuberculous cow ; but the owner is injured, and often calamitously, by keeping herds of cows and not learning, by means of the tuberculin test, that some of them are tuberculous."

Does tuberculin cause tuberculosis?

Another objection which has been urged against tuberculin is refuted in the following words by Jensen,[4] thus confirming the views of many distinguished authorities.

"It has been claimed that cows—even those appearing clinically sound—frequently give milk containing tubercle bacilli after a tuberculin reaction, and, therefore, it has been advised to prohibit the use of unboiled milk from such cows, for a few months after the tuberculin test.

1. U.S. Dept. of Agri. Yearbook for 1901, pp. 581-92, Washington, 1902 ; quoted B. A. I., Bull. 38, p. 52.
2. See The Rural World, June, 1909, p. 106.
3. Circular 95.
4. Milk Hygiene, p. 73.

"This assertion is wholly untenable, and is completely lacking in proof."

Russell and Hastings[1] state that "Tuberculin has no ill effect whatever on healthy animals, and no harmful effect on tuberculous animals. It does not, in the amounts used in testing, have any effect on the progress of the disease in the animal, nor can it in any way produce the disease. With many of our best herds it has been used regularly for ten to fifteen years with absolutely no injurious effects. The statements that the test causes abortion or other ailments are without foundation. The flow of milk is not changed to an appreciable extent, even in the case of tubercular animals."

MODIFICATIONS OF THE TUBERCULIN TEST.

Simplified tests

During the last few years it has been found that to secure a reaction to tuberculin it is not necessary to inject the re-agent under the skin, neither is it necessary to take temperatures, for in a tuberculous animal the tuberculin produces surface inflammation readily visible to the eye. Although these modified tests have not gained general acceptance on account of being less certain in action, they nevertheless appear to possess certain advantages in ready and simple applicability, less liability of being counteracted by dishonest practices, and may be used to check doubtful reactions without waiting the lapse of the customary six weeks[2] to six months.

Von Pirquet

According to Dr. Henry L. K. Shaw,[3] "In April, 1907, von Pirquet, of Vienna, published the results obtained from cutaneous vaccination with tuberculin. He found a characteristic reaction in tuberculous individuals, and formally announced the discovery of the cutaneous tuberculin test. About a month later Wolff-Eisner, of Berlin, inspired by von Pirquet, published the results obtained from instilling a drop of a weak solution of tuberculin on the conjunctival mucous membrane. He found a constant and specific reaction in tuberculous subjects, and named it the conjunctival tuberculin reaction. A month after the publication of Wolff-Eisner's discovery, Calmette, of Paris, published a series of similar experiments, but undertaken independently, with identical results. He employed the term ophthalmic test. Moro, of Munich, recently found that he could obtain a specific reaction on the skin of tuberculous individuals by simply rubbing in an ointment containing tuberculin. This he termed the percutaneous test. These tests all depend on the local effect of tuberculin on the tissues, and the vast amount of literature that has appeared in the past twelve months shows how eagerly the medical profession has grasped at a simple, harmless, and inexpensive method

1. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 13.
2. Professor A. R. Ward says six weeks is not long enough (California Cultivator, Nov. 11th, 1909).
3. 6th I. C. on T., Vol. 2, p. 547.

of obtaining an early diagnosis in that all-too-frequent disease tuberculosis."

" CUTI "-REACTION IN TUBERCULOSIS DIAGNOSIS.

According to the Journal of Comparative Pathology and Therapeutics,[1] M. Vallée has made some experiments in order to discover whether this new test of tuberculosis is applicable to the lower animals. In healthy animals (cattle, horses, or guinea-pigs) when one shaves and scarifies an area of skin and places on it some drops of strong tuberculin diluted with an equal volume of boiled water there is, as a rule, no appreciable reaction. It is important to select for site of operation a region which the animal cannot reach with its teeth, feet, or horns. The sides of the withers is a convenient place. On the other hand, in operating similarly on twenty-five tuberculous animals, Vallée obtained, by the twenty-fourth hour after the operation, a very manifest cutaneous reaction. The skin over a breadth of several millimetres on each side of the scarified areas became thickened and infiltrated and formed a painful greyish red swelling, the size of which varied according to the intensity of the reaction.

Vallée applies it to cattle

When the scarifications were sufficiently close together there resulted an actual cutaneous plaque which was œdematous, had lost its pliability, and was very sensitive on palpation. The lesion became more marked from the thirty-sixth hour, and it was most distinct towards the forty-eighth hour. It still persisted with very marked characters four and five days after the operation. The reaction is not accompanied by any very distinct thermal reaction and preserves its diagnostic value for ten, fifteen, or twenty days.

The " cuti "-reaction and the reaction which follows the subcutaneous injection of tuberculin correspond to each other in that—

(1) Animals which give marked reactions to the ordinary methods of tuberculination also give good " cuti "-reactions ; and

(2) In neither case is the intensity of the reaction proportionate to the severity or the extent of the tuberculous lesions existent in the inoculated subject.

With regard to the question as to whether it would be possible to obtain simultaneously in the same subject both " cuti " and general reactions, Vallée, who made many attempts in this direction, found that—

(1) In tuberculous bovines which received at the same time as a dose of tuberculin hypodermically injected a quantity applied to a scarified area of skin, the " cuti "-reaction was hardly noticeable, although the thermal reaction was always typical and well marked.

(2) The " cuti "-reaction was not very evident when the subcutaneous tuberculin test had been practised within the two or three

1. Jour. of Comp. Path. and Ther., Sept., 1907, p. 260 ; March, 1909, p. 12.

days immediately prior to the application of tuberculin to the scarified skin.

(3) On the other hand, when a dose of tuberculin was hypodermically injected into bovines on the fifth day of a "cuti"-reaction, pronounced and typical thermal reactions were obtained in addition to the cutaneous reaction already in evidence.

Check on 'doping'

Dr. J. G. Rutherford,[1] though very doubtful in a general way of the reliability of the tuberculin test, paid a tribute to Professor Vallée's important discovery which had defeated the old method of dosing beforehand with tuberculin (to prevent reaction).

As showing the reliability of the cutaneous reaction, we may refer to the work of Engel and Bauer,[2] who, having used it on about 300 human cases, conclude that it is of great diagnostic value.

While Medin[3] believes that, in this test, "....even the least sign of a reaction is of importance," Raw[4] considers a positive reaction only confirmatory of suspected tubercle, but a negative reaction is of great value in excluding tubercle altogether. He has found the test to be remarkably certain and reliable.

Miller and Woodruff[5] conclude the cutaneous tuberculin reaction to be fully as reliable as the hypodermic test.

Joseph,[6] however, recommends a modification of the cutaneous reaction, which he claims is more reliable and possesses other marked advantages. Hereunder we give an abstract[7] of the original paper.

THE DIAGNOSTIC VALUE OF THE INTRA-CUTANEOUS TUBERCULIN TEST.

"The unreliability of the results obtained with the cutaneous tuberculin test suggested to the author the desirability of modifying the technique with the object of obviating this. In the author's opinion the results obtained depend upon the absorptive capacity of the animals' skins and upon the use of a sufficient quantity of tuberculin. These two conditions are met by the intra-cutaneous injection of the tuberculin.

"**Technique of the Method.**—The seat of operation is the side of the neck. Clipping and shaving of the place have been given up without impairing the safety of the method or the accuracy of judging the effect of the injection.

"The thickness of the skin is first determined in the manner described in Romer's account of Lignieres' method. With a simple scale two points 5 cm. apart are marked at the seat of the injection,

1. 6th I. C. on T., Vol. 4, pt. 2, p. 871.
2. Quoted by Floyd and Bowditch, 6th I. C. on T., Vol. 2, p. 498.
3. 6th I. C. on T., Vol. 2, p. 389.
4. The Lancet, Mar. 26th, 1910, p. 846.
5. 6th I. C. on T., Vol. 2, p. 490.
6. Berl. Tier. Wochens., No. 46, Nov. 18th, 1909, p. 847.
7. Reprinted from the Jour. of Comp. Path. and Ther., Vol. 23, pt. 4, Dec., 1910, p. 359.

the thumb and forefinger of the left hand being placed on these points. The scale is then removed, and the finger and thumb are drawn together and the thickness of the included fold of skin is measured. There is a rather marked variation in the thickness of the fold of skin in different breeds and in animals of different ages. With practice this method of measuring the thickness of the skin becomes unnecessary. The skin in the neighbourhood of the seat of injection must be examined for nodules or swellings before the injection is made, and it must be washed with alcohol to avoid accidental infection of the puncture with resulting non-specific swelling. In order that an accurate dose may be introduced with certainty a 1 c.c. syringe, graduated in tenths, is used for the injection. In making the injection, a longitudinal fold of skin is grasped between the thumb and forefinger, and a puncture is made from above downwards with a fine but strong hypodermic needle just under the surface of the skin, so as to avoid making a subcutaneous injection. The size of the needle is of importance, because the thicker it is the greater the non-specific swelling due to the mechanical injury. After the injection a small swelling about the size of a pea is seen, indicating that the injection has been intra-cutaneous. The injected fluid is dispersed by massage. More than 0·1 c.c. should never be injected, so that there may be minimal traumatic swelling. The dose of 0·2 c.c. injected by Foth appears to be too large, according to the author [Joseph], because of the difficulty of differentiating between the traumatic and the specific reactions.

" The choice of an appropriate dose of tuberculin is of the greatest importance. In France the dose selected is from 0·01 to 0·02 c.c., but the tuberculin varies greatly in strength, and it is difficult to say whether the correct quantity of tuberculin is injected. It is conceivable that the dose used by the French authors is too small to detect all tuberculous animals. In any case it would be too small as compared with the State-tested German tuberculin. As shown by the recently published work of Foth, he had more errors when he used the dose prescribed by the French authors than when he employed a considerably increased dose. Finally, it is important to know the specific activity of the selected preparation. The German State-tested preparations are of guaranteed activity, and, therefore, suitable for strictly comparative tests. According to the author's experiments, the proper dose of tuberculin, preferably 'Behringwerk,' is 0·05 c.c., diluted with an equal volume of physiological salt solution.

" The result of the injection is controlled at intervals by the already described method of measurement of the thickness of the skin. It is advisable to take the first measurement forty-eight hours after the injection, as slight traumatic alterations may be present at twenty-four hours and lead to erroneous conclusions. After forty-eight hours these will certainly have disappeared. The measurement taken at the end of the third or fourth twenty-four hours is the critical one, for in the great majority of cases the swelling is at that time at its height. In practice it should be sufficient to take one measurement after seventy-two hours.

" **Nature of the Reaction.**—A positive reaction is indicated by the appearance at the seat of injection of a characteristic, soft, œdematous, painful swelling of varying diameter. A recognisable reaction may be already present twenty-four hours after injection. In that case there is marked hyper-sensitiveness, but generally the reaction is first clear on the second day, and reaches its maximum on the third, or, more rarely, on the fourth, day. The swelling is the decisive symptom, the occurrence of reddening and subsequent necrosis of the skin not being observed as a rule.

" Reactions which cause an increase in the thickness of the skin of 0·75 cm. or more are so marked that they are recognisable at a glance after a little experience. In cases where the swelling amounts to 0·4–0·7 cm. the method of measuring is valuable, for this slight swelling is due to a specific hyper-sensitiveness, and may with safety be referred to tuberculosis. The author considers those cases in which the swelling amounts only to 0·2–0·3 cm. as doubtful, and advises a repetition of the test on the other side of the neck with 0·1 c.c. of undiluted tuberculin.

" In animals free from tuberculosis the seat of injection remains quite flat, the slight wound caused by the needle disappearing in forty-eight hours. This non-specific swelling in rare cases may measure 0·4 cm. ten to twelve hours after injection ; after twenty-four hours it measures at the most only 0·3 cm., and after forty-eight hours it has quite disappeared.

" In the first series of animals nine were tested, and of these seven reacted to the test. When the animals were slaughtered lesions of tuberculosis were found in the seven that had reacted, and the other two were found to be free from the disease.

" In the second series of animals twenty-two were tested. Each received 0·05 and 0·1 c.c. at different places. Of these thirteen reacted, and lesions were found in twelve of the reactors. The author considers that the animal that reacted without lesions being discovered was in reality affected, but that the disease was in a latent condition. No lesions were found in any of the non-reactors.

" In the third series twenty-five animals were tested in the same way as the second series. In this series there were eleven reactors and fourteen non-reactors, the result of the test being supported in every case by the discovery of lesions on slaughter. One animal in this series gave a doubtful reaction at the place where the dose of 0·05 c.c. had been injected, but the reaction was quite clearly positive at the seat of the 0·1 c.c. injection.

" In the fourth series nineteen animals were tested, ten being positive, eight negative, and one doubtful. The reactors were all found to be diseased, as was also the doubtful reactor. The non-reactors were found to be free from the disease. In the case of the doubtful reactor the author was able to measure the swelling after forty-eight hours only, and he thinks that had he been able to take measurements later the result of the test would have been positive.

"Fifth series.—Fifty-one animals tested, thirty-seven reacted and fourteen did not. The results of the test were confirmed in every case at the autopsy.

"**Conclusions.**—A swelling of 0·3 cm. or more during the third or fourth twenty-four hours after injection indicates that the animal is tuberculous. Should the swelling not exceed 0·2 cm., the author advises a repetition of the test, using in all cases 0·1 c.c. of the particular brand of tuberculin mentioned.

"There is no reaction in sound animals.

"The advantages claimed by the author are the simplicity of the technique and the easy interpretation of results. The practitioner is not bound to any particular hour for the examination of animals that have been tested. The method is superior in that its results remain recognisable for a longer time, and errors, such as are met with in the subcutaneous method, through accidental elevation of the temperature, are more easily avoided. The test causes no diminution in the secretion of milk. It is more economical in that far less tuberculin is necessary."

THE DERMO-REACTION IN TUBERCULOSIS DIAGNOSIS[1] OF PROFESSOR T. LIGNIERES

(Director of the Institute of Bacteriology, Department of Agriculture, Buenos Ayres).

EPITOME OF PAPER READ AT THE SIXTH INTERNATIONAL CONGRESS ON TUBERCULOSIS, WASHINGTON, 1908.

"If a few drops of crude tuberculin are rubbed into the skin of a tuberculous patient, freshly shaved, without any scarification, a most characteristic reaction is produced. The author proposes to call von Pirquet's test 'cuti-reaction,' and his own modification 'dermo-reaction.' Neither of these reactions produce the slightest thermic or general disturbance; they may be repeated successfully to an almost unlimited extent at very short intervals. The two reactions may be combined by rubbing the tuberculin on the entire surface instead of merely placing a small quantity on the superficial incisions. In cattle, tuberculin rubbed into the skin after shaving, produces, in twenty-four hours to forty-eight hours, a specific inflammatory reaction of variable intensity, from simple redness to œdematous tumefaction, with or without vesicular eruption, terminating in the formation of crusts. The reaction is easily produced under the same conditions in the tuberculous rabbit and guinea-pig, but it usually takes the œdematous form.

1. Reprinted from Rept. of 6th I. C. on T., Vol. 4, pt. 2, p. 818.

"The possibility of early diagnosis without scarifying the experimental animals.—In man the author's [Lignieres] dermo-reaction is also capable of doing excellent service.

"**Technic of Dermo-reaction.**—The skin on the inner surface of the arm at the level of the biceps is lathered with an ordinary shaving brush, over a surface of about 20 square cm., and then shaved with a safety razor in every direction."

Lignieres described the Advantages of the Safety Razor.—"After removing the excess of soap with clean water and drying the shaved surface with a cotton pledget, from five to six large drops of crude tuberculin (not diluted) are rubbed on the prepared surface. To hasten absorption, the skin is put on the stretch with the left hand and rubbed with a finger of the right hand, protected with a rubber finger cot or a small cotton tampon held in a pair of forceps. Absorption of the tuberculin may be hastened by previously rubbing the surface with alcohol and xylol. This causes redness of the skin, and as soon as this dries, the tuberculin is applied with friction.

"**Results of the Procedure.**—In normal individuals the skin remains entirely normal. In tuberculous individuals there is a specific reaction manifesting itself chiefly in an eruption, and apparent, as a rule, in twenty-four hours, sometimes delayed for forty-eight hours, and in exceptional cases longer. The treated surface is covered with papules ranging in colour from a very pale pink mixed with yellow or grey to dark red or even purple. The base of each papule is surrounded by an areola of the same colour. Sometimes the papules are very numerous and coalesce to form confluent little islands, or even a large red patch of an œdematous appearance.

"The eruption may stop at the stage of a simple papule, which disappears in four or five days practically without leaving a trace, except to the sense of touch. When the reaction is more intense, the eruption goes on to the vesicular, and occasionally to the vesicopustular, stage, with a formation of true crusts. The latter is rare in man. The small vesicles with yellowish white centres persist for several days, then gradually fade, and by the end of a week disappear entirely in almost every instance. Their disappearance leaves a small red or brownish spot which persists for weeks. This pigmentation is proportionate to the intensity of the eruption. The pigmentation is often accompanied by the formation of white epidermic pellicles or scales on the surface and around the papules; these scales sometimes assume the form of small epidermal crowns. Some itching attends the development of the eruption, as in the case of a vaccination; but fever and constitutional symptoms never develop.

"**Different Degrees of the Reaction.**—(1) Isolated papules not exceeding ten in number. (2) More than two papules, some of them confluent. (3) Confluent papules forming a patch on all or part of the treated surface. The intensity of the eruption must also be taken into account, the inflammatory action of the skin being variable in each of the three degrees of the reaction.

"**Significance.**—In general, and especially in adults, the 'cuti'-reaction develops its characteristic degree of intensity during the first twenty-four hours. There are many exceptions to this rule. In young children especially, the dermo-reaction may in the beginning be of the first degree, and in the course of several days go on to the second or even the third degree. Successive crops are sometimes observed in young subjects, so that various stages of the reaction may be present at the same time. When the eruption appears in crops the duration is longer than when the papules all come out at once. Observations on a number of patients, both normal and tuberculous, form the subject of a later paper.

"**Comparative Sensitiveness of the Ophthalmo-, Dermo-, and 'Cuti'-Reaction in Man.**—The ophthalmo-reaction is the most sensitive of all the diagnostic procedures. The dermo-reaction and 'cuti'-reaction are equally constant, except in cachectic cases, in which the clinical diagnosis is, fortunately, quite easy. (In the latter class the 'cuti'-reaction sometimes proves positive after several attempts, giving it a slight advantage over the dermo-reaction in this class of cases.) A positive dermo-reaction is more significant than a positive oculo-reaction. It always indicates the presence of tuberculosis. In ordinary practice the dermo-reaction should be employed first, and if it proves negative, the diagnosis may be completed by means of the ophthalmo-reaction.

"**Advantages of the Dermo-Reaction.**—Ease of application, painlessness, absence of danger of spontaneous infection, since the skin is not broken. The reaction when positive is absolutely characteristic, and therefore easily interpreted by beginners. A positive cutaneous reaction is of absolute value. In private practice, the dermo-reaction should be employed first. If it is positive, the diagnosis is asserted; if it is negative, it is presumptive evidence against tuberculosis, and the diagnosis should be controlled by means of the ophthalmo-reaction. The dermo-reaction is particularly accurate in children—I have never seen the slightest ill-effect from its use—while the 'cuti'-reaction is occasionally not well tolerated, and is, besides, difficult to interpret. As for the ophthalmo-reaction in young subjects, it may produce or revive—in a few rare cases, it is true—permanent and very unpleasant ocular lesions."

OPHTHALMO-TUBERCULIN TEST IN CATTLE.

Abstract of Paper by David S. White and Eugene McCampbell, Ohio State University.[1]

Vallée was probably the first to apply the ophthalmo-tuberculin test to domestic animals, and demonstrated that it possessed some value as a diagnostic agent. Later, Vallée employed the test for cattle.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 804.

Since then Lignieres, in South America, and White and McCampbell, in the United States, have worked on it. The following account refers to the work of the two latter investigators.

At first White and McCampbell tried the tuberculin as prepared by Calmette, but as no results followed they tried other forms. The tuberculin which gave the best results was procured from the Bureau of Animal Industry, Department of Agriculture, United States. The method employed consisted in having an assistant grasp the muzzle and horn of the animal and so rotate the head that the eye to be instilled[1] is brought into as nearly a horizontal position as possible. The lower lid is then elevated, and 0·25 c.c. full-strength tuberculin instilled from a sterile eye-dropper into the conjunctival sac, the test liquid being allowed to flow over the lower portion of the bulbar conjunctiva. Gentle massaging of the eyeball through the lid promotes absorption. Too much manipulation, however, induces excessive lachrymation (watering of the eye) and consequent washing out of the reagent. It is also advisable not to feed hay while the reaction is developing, on account of the cattle rubbing off the exudate which may flow.

"**Reaction.**—Our experiments," White and McCampbell state, "show that the ophthalmo-tuberculin reaction varies greatly in different animals, and also, to a lesser extent, in one and the same animal. In one cow, for instance, a very marked reaction would be preceded or succeeded by a greater or lesser reaction. In other words, the reaction in a given animal is not always uniform. The intensity of the reaction varied from a mere congestion of the conjunctiva, especially marked in the *membrana nictitans*,[2] to a pronounced fibrinous conjunctivitis with profuse exudation. Such a reaction, taken from our notes, may be considered of typical intensity.

"'In the right eye, beginning from six to eight hours after instillation of the tuberculin (0·25 c.c.) the lids appear slightly swollen. Photophobia and lachrymosis are present. Within sixteen to eighteen hours there appears upon the conjunctiva a thin layer of whitish-grey membrane. This is particularly marked on the bulbar conjunctiva[3] covering the sclera,[4] and on the *membrana nictitans*, which is highly reddened.

"'Thin films of this membrane are constantly being washed down over the cornea, where they appear as moveable opacities, passing downward to the lower lid. The eyelashes are agglutinated (stuck together) with greyish-yellow exudate. The episcleral vessels are dilated. From the inner canthus (corner) is a discharge of straw-coloured exudate which dries to form crusts. The left eye is normal.'"

It is evident that some experience is necessary in the application

1. White and McCampbell always used the right eye.
2. "*Membrana nictitans*"—Haw.
3. "Bulbar conjunctiva"—the glistening covering of the eyeball.
4. "Sclera"—white of the eye.

of this test, as the above-named investigators remark in reference to two animals which did not react to the ophthalmic test, but reacted later to the usual tuberculin test, and which on *post-mortem* examination were found tuberculous. "It is very possible that these two animals did give slight reactions, which, occurring during our first experience with this method, may have been overlooked."

A valuable point in favour of this test lies in the probability that the more advanced the tubercular process in the body, the more pronounced the ophthalmo-tuberculin reaction.

White and McCampbell differentiate the results they observed into five classes :—

(1) Negative. No difference observed in the eyes.

(2) Doubtful. Slight redness of conjunctiva.

(3) Slight engorgement of palpebral conjunctivæ with exudation.[1]

(4) Marked engorgement of the whole conjunctiva, photophobia,[2] lachrymation, exudate.

(5) Very marked reaction.

Conclusion and Summary.

"(1) The ophthalmo-tuberculin test is of limited value in the diagnosis of tuberculosis in cattle. In some cases the reaction is very slight (hyperemia). In others, pronounced congestion with profuse exudates are noted. Accuracy of observation is important. *We are inclined to rely primarily on the result of the first instillation of tuberculin.* Second instillations rarely elicit reactions in non-tubercular animals.

"(2) In the majority of animals tested the reaction increased in its intensity with each subsequent instillation of tuberculin. This fact indicates the development of a local hypersusceptibility of anaphylaxis associated with a partial immunity. Von Pirquet calls this condition 'allergie.'

"(3) It is possible in some cases to create a condition of 'allergie' in healthy cattle, when spaced instillations of tuberculin are made. It is evident, therefore, that the result of the first instillation of tuberculin should be made the only basis of diagnosis. Rosenau and Anderson have called attention to this point in regard to the human subject.

"(4) When repeated instillations of tuberculin are made on the conjunctiva at short intervals (twenty-four hours, etc.) a local immunity (antianaphylaxis) results. If the instillations are separated two weeks or more, anaphylaxis results.

"(5) We hold, therefore, that if tuberculin (0·1 c.c.) is carefully instilled into the conjunctival sac, and the condition of the instilled eye carefully compared with the opposite eye, and a reaction of

1. The eyelids become swollen, watery, and red inside.
2. "Photophobia"—avoidance of light.

varying intensity results in from ten to twelve hours after the first instillation, a tubercular lesion is present.

"(6) While in our first experiments we were inclined to believe that a subcutaneous tuberculin injection given previous to the ophthalmic test would slightly inhibit it, we have since become convinced that this is true only to a limited extent. In some cases, the ophthalmic reaction is exaggerated by a subcutaneous injection of tuberculin.

"(7) The primary ophthalmo-tuberculin reaction is in direct proportion to the extent of the tubercular process in the body. The more extensive the tubercular lesion, the more anaphylactic the animal is. This is in direct variance with the condition in the usual subcutaneous tuberculin test.

"(8) We are inclined to believe that the ophthalmo-tuberculin test will reveal tuberculosis at as early a stage as the usual subcutaneous tuberculin test.

"(9) The ophthalmic reaction is of no value in determining whether vaccinated cattle are actively tubercular or not, or in demonstrating any hypersusceptibility in the offspring of tubercular cattle."[1]

Calmette,[2] in discussing his results with human beings, claims that "These truly specific and non-febrile local inflammatory reactions, which are free from the objections incident to the subcutaneous injection of various kinds of tuberculin, have a diagnostic value assuredly much greater than that of any laboratory procedure which until recently we have had at our disposal."

THE INTRADERMO-REACTION TO TUBERCULIN IN ANIMALS[3]

By Professor G. Moussu (*of the Veterinary School at Alfort, Paris*) and Dr. C. H. Mantoux (*formerly House Surgeon of the Paris Hospitals and Consulting Physician at Cannes*).

Under the title of "Intradermo-Reaction to Tuberculin," one of us[4] has so named the result of injection of a tuberculin solution into the skin itself. In human subjects, the results of an injection of ·01 milligramme have been absolutely demonstrative in the diagnosis of latent, doubtful, and averred tuberculosis. The very rare cases in which the test has been without effect were either those of subjects in a state of cachexy or decline. From that moment, it became interesting to transfer this test to the animal world in order to see if the effects would be comparable as experiments, and if any practical benefit might be derived in cases of latent tuberculosis in different species. With this object, we have sought to determine, first, the effects of the test on animals of the bovine class already known to be tubercular, and on other animals known to be absolutely healthy. If, under these conditions, an injection is made in the thickness of the

1. For complete report see Jour. of Exp. Med., Mar., 1908, and Sept., 1908.
2. 6th I. C. on T., Special Vol., p. 79.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 821.
4. C. H. Mantoux, "Intradermo-Reaction à la Tuberculin," Comptes rendus de l'academie les Sciences, Aug. 10th, 1908.

skin (dermis, derma) of $\frac{1}{10}$ to $\frac{1}{5}$ c.c. of crude tuberculin, diluted ten times with physiological (*salt solution*) or distilled water, *i.e.* of 1 to 2 centigrammes of tuberculin, according to the size and weight of the subject, it will be found—

(1) That in all healthy animals, without exception, the test will have no immediate effects and will be without future results. There remains hardly a trace of the puncture after forty-eight hours.

(2) That in all tubercular animals, from the moment of the injection, a local very marked reaction is produced, evidenced by the increased sensibility of the skin, by the thickening of the derma, and by the appearance during the forty-eight hours following the injection of a circular patch of subcutaneous œdema, which may vary in size from that of a five-franc piece to that of the palm of the hand.

The reaction, which is visible after twenty-four hours, attains its maximum after forty-eight hours, and commences to recede during the fourth or fifth day. Its disappearance is very slow, and in certain subjects the local modification is sometimes still very marked after about ten days.

For this intradermo-reaction a Pravaz syringe of 1-c.c. capacity, graduated and provided with a cursor (slider), is sufficient. Each syringe full of diluted tuberculin contains five or ten doses, according to the size and weight of the subjects.

The skin proper is easily penetrated by means of a short, fairly fine hollow needle. Should the point of the needle, however, by mischance go through the skin and enter the tissues beneath, it is an easy matter to so far withdraw it that its point shall be in the substance of the skin itself.

In subjects with non-pigmented skin (*e.g.* animals of the bovine species of the Charolaise and Nivernaise races) the reaction is usually accompanied by the appearance of a small hæmorrhagic intradermic patch, which is first of a free red, then a reddish brown, towards the end slightly violet, and of which the dimensions vary between the size of a lentil and that of a fifty-centime or one-franc piece (6d. or 1s.). This patch begins round the point of the puncture on the culminating part of the œdematous[1] zone which characterises the reaction. All round the œdematous reaction patch, the skin has preserved its usual softness, which easily permits of determination of the intensity of the local reaction by comparative palpation. In healthy subjects, the skin always preserves its normal softness even at the point of injection, so that for a veterinary surgeon or physician the detection of the positive or negative reaction is quite easy without special training.

This specific intradermic-reaction may be obtained on any part of the surface of the body—of the neck, shoulder, or other region. Unfortunately, if practised under these conditions, it presents the

1. "Œdematous"—doughy.

inconveniences experienced with the "cuti"-reaction, which one of us has already briefly mentioned.

If the skin is very thick and its regular folds are already difficult for examination in its normal state, the discrimination of the local œdematous reaction becomes even more difficult and might leave the inexperienced in doubt. On the other hand, in subjects with pigmented skin, which form the vast majority of our French bovine races, the central hæmorrhagic[1] spot cannot be seen. These are a few very real inconveniences which also apply to the "cuti"-reaction and which might prevent the application of the test in practice. We have, therefore, endeavoured not to modify the technical test, but to find a better location for the intradermo injection.

This region has been found without much difficulty, and the results of the operation are then so easily visible that they can be recognised by any one. It is only necessary to look. In all subjects of the bovine species, between the base of the tail and the anus, there are two lateral cutaneous folds at the bases of which the skin is very fine and supple, not covered with hair, but provided with an elastic subcutaneous tissue which is very abundant. When the intradermic injection of tuberculin (two to four drops of one-tenth strength) is made in one of these folds, preferably in the principal or middle part, the reaction, if positive, is similar to that in other parts of the skin; and, if negative, remains without effect. Twenty-four hours after the operation, the result is easily diagnosed, but the maximum is only attained about the forty-eighth hour. If the result is positive, it is sufficient to lift the tail slightly to see that the subcaudal fold which has been operated on has doubled or trebled in thickness, whereas the opposite one remains exactly as before. The difference between the two is very evident to all.

Usually the œdematous infiltration of the subcaudal fold takes ovoid form at the point of inoculation, and attains the dimensions of a Barcelona nut, an almond, or walnut.

In other cases the infiltration descends into the depth of the cutaneous fold, transforming it into an elongated pad, and finally, if the injection has been made too far down, the œdematous infiltration gains laterally and in the direction of the edge of the anus, suggesting a little deformity and deviation. The feel of the subcaudal fold under the reaction, as compared to the opposite normal fold, gives a very clear indication of cutaneous and subcutaneous infiltration, of which the sensibility varies a little according to the subject. From the fourth day, the reaction decreases; the tension of the tissues diminishes slowly, but to an experienced eye may be visible for a fortnight.

In non-tubercular subjects the injection has no effect—the two cutaneous folds retain their normal aspect, suppleness, and mobility.

1. "Hæmorrhagic"—bleeding beneath the skin.

The comparative palpation test reveals nothing except, perhaps, a small hardening, the size of a grain of wheat or so, at the point of inoculation, but this disappears very rapidly. Although the place for injection is a region liable to be frequently soiled, we have always made these injections without previous local disinfection, and we think that in practice there will be no inconvenience in operating in this way. The number of our inoculations seems to justify this. In short, it is possible, without soaping, shaving, rubbing, or scarifying, to discover very quickly and with great security the cases of latent or hidden tuberculosis by an extremely simple procedure, which, at one stroke, obviates a lot of precautions and obligations necessary in the subcutaneous injection of tuberculin, the ophthalmo-reaction, or the "cuti"-reaction.

As will be seen from the table of our statistics, in some subjects, after reacting, a small superficial scab has been noticed sometimes at the base of the point of puncture, the size being about that of a fifty-centime or one-franc piece. This scab appears at the end of five or six days in the shape of a small brown crust, which detaches itself slowly in ten to fourteen days.

The time required for performing the test operation is not more than one minute per animal, and for observing the results ten minutes for thirty-six animals.

The test only causes a trifling decrease in the milk yield.

[From the table given by the authors we may quote the main results as under—

Two cows gave positive reactions, and were afterwards found to be tubercular.

Nine cows were artificially infected with tuberculosis. All reacted to the test.

Three cows known to be healthy did not react.

A larger number of cases are given in which the reaction was relied upon as a diagnostic, but as the actual facts were not positively known we omit them.

In a herd of thirty-six draught oxen, which had been cleared of tuberculosis three years previously, and in which no animal was allowed to remain for more than four or five years, only one reacted positively to the intradermo-tuberculin test, and it was one of the few remaining of the stock which was believed to have been cleared. On slaughter, this beast was found tuberculous.

Nine cattle were experimently inoculated with tuberculosis, and on testing yielded positive results to the test.

On account of the difficulty of applying the subcutaneous tuberculin inoculation to swine, and the still greater difficulty of taking the temperatures, the animals being so restive, the authors recommend the intradermo test. The ophthalmo reaction is also difficult when applied to hogs, especially in observing the results.]

Conclusions.

(1) The intradermo-reaction to tuberculin as we have defined it has shown itself in our investigations quite sensitive enough to reveal tuberculosis in the animals (cattle, hogs, goats).

(2) The intradermo-reaction is characterised by local thickening of the skin, œdema[1] (in bovines), and sometimes the appearance of a central red spot (in hogs).

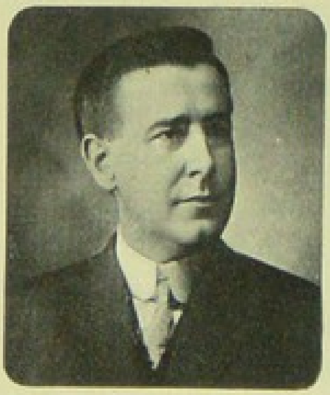
(3) This local reaction does not usually cause any general disturbance, causes little or no fever, no loss of appetite, little or no loss of milk. It develops without any change in the ordinary conditions of the life of the animals, and without its being necessary to take any measures or special precautions.

(4) It has none of the disadvantages of the ophthalmo and cutaneous reactions, and presents all the advantages of the subcutaneous injection of tuberculin.

(5) It reduces the obligations of the operator to a minimum, by dispensing with every preparatory or supplementary measure (taking of temperatures, denudation of the skin, etc.).

(6) It is applicable to every kind of domestic animal.

WARD AND BAKER ON INTRADERMAL TEST.



Archibald R Ward
Chief of the Veterinary Corps, United States Bureau of Animal Industry, Manilla, Philippine Islands; sometime Director, State Hygienic Laboratory, University of California, Berkeley, California.

Important confirmation of the reliability and convenience of this simplified test is afforded by the work of Ward and Baker,[2] who approached it in four directions:

(1) Intradermal test followed by autopsy.

(2) Comparison of intradermal and subcutaneous tests without slaughter.

(3) Comparison of intradermal and subcutaneous tests with slaughter.

(4) Intradermal test immediately following subcutaneous test.

(1) *Intradermal Test followed by Autopsy.*

These investigators state that "The application of the classical subcutaneous tuberculin test to range cattle under range conditions is impracticable. The e :citement resulting from the necessary frequent handling makes temperature records valueless. This is unfortunate in two respects. First, it prevents the possibility of reducing the number of tubercular animals on the range by sending diseased ones to the abattoir for slaughter under competent inspection. Second, it prevents the exportation of certain desirable breeding animals to countries requiring the tuberculin test as a pre-requisite to shipment.

1. "Œdma"—puffy and doughy swelling.
2. "Experiments with the Intradermal Test for Tuberculosis in Cattle," by Ward and Baker, Amer. Vet. Review, Vol. 38, No. 2, p. 184, Nov., 1910.

"Through the kindness of Miller and Lux, Inc., one hundred head of range cows, shipped to their abattoir for slaughter, were placed at our disposal for the purpose of studying this test. These cows were subjected to the test and afterward slaughtered to check the accuracy of the diagnosis.

"The hundred animals used for the experiment were taken at random from shipments of range stock, cut out for slaughter, and were all in good condition. They were not specially selected.

"The requirement that the tuberculin be injected between the layers of the skin necessitated the use of a very fine, short hypodermic needle. We used a 1-c.c. hypodermic syringe, graduated to minims, of a type used by dentists. We found the kind of tuberculin specified by Moussu and Mantoux in the stock of the Cutter Laboratory, Berkeley. It bore this label: 'Tuberculin O.T. (Original) Serial Dilution No. 5. 1 c.c. contains 100 mg.' The dose uniformly administered by us was a trifle over 3 minims, the equivalent of 2-10 c.c.

"In making the injection the cows were run, one at a time, into a chute, which was just long enough for one animal. The rear end of the chute was closed by one bar placed immediately above the hocks. Animals especially wild were held against this bar by a lariat around the horns and stretched taut by a vaquero and horse. The operator stood squarely behind the animal in making the injection. The right subcaudal fold was pulled out to view with the left hand and held while the injection was made with the right hand. No precautions were taken to prevent infection at the site of injection and no evidence was found to indicate danger in this technique. In making the injections we felt the need of a syringe having a gauge on the piston, so that the work could be done quickly without the necessity of watching the graduations while injecting.

"In one instance, the injection was made while the animal was thrown and held by two vaqueros, as is usually done in branding on the range. This circumstance illustrates the fact that a chute is not absolutely necessary.

"Forty-eight hours after injection the cows were again run through the chute and roped to facilitate careful examination. The operator, standing immediately behind the animal, lifted the tail to a horizontal position with one hand, and with the other compared the thickness of the two subcaudal folds. At this time the animals were marked with ear tags to ensure identification on the killing floor.

"On completion of the examination the cows were driven to the abattoir and slaughtered immediately. The regular routine of Federal inspection, involving an examination of all the viscera, all the visceral lymphatic glands, and all the superficial body glands, was followed, the axillary and popliteal glands being the only ones not reached."

A table is given showing the results of intradermal test and result on autopsy from examination of the following parts:

Cervical, bronchial, prescapular, mediastinal, portal, mesenteric, iliac, external inguinal, internal inguinal, precrural, sublumbar, and supra-mammary glands; also lungs, liver, pleura, and peritoneum.

Ward and Baker continue, "As a result of these autopsies we confirmed twenty-eight out of thirty cases which we had considered to be positive reactions. Of four reactions which we considered questionable, three proved positive on *post-mortem*. In two that we considered positive, no lesions were found. Fifty-nine which we considered non-reactors proved negative on autopsy. Seven that we considered as negative showed lesions. We believe that with our present knowledge and experience, the number of those diseased and classed as negative would be very materially reduced.

"In judging what constitutes a reaction one must differentiate between the slight thickening which nearly always is noticeable at the forty-eighth hour, and the œdematous infiltration characteristic of a reaction. The former is described by Moussu and Mantoux as the size of a grain of wheat. In our experience, such nodules, if spherical and less than a quarter of an inch in diameter, have not been significant. We have found these small nodules to be always much firmer than the diagnostic œdematous enlargement.

"The significant œdematous swelling varies slightly in general conformation. In some cases it assumes a spherical form, and any such swelling one half inch in diameter or over should be regarded as a positive reaction. We have observed such swellings approximately two inches in diameter. In other cases, a reaction is indicated by a more or less oval or circular flattened œdematous mass about the size of a quarter dollar and twice the thickness of that coin. These flattened infiltrations may reach the size of a dollar and double its thickness.

"Our experience has indicated that there is difficulty in interpreting the significance of a swelling varying from a quarter to a half inch in diameter. We encountered two animals whose swellings were of this size. One of them proved on autopsy to be a generalised case with widespread miliary lesions. The other showed no lesions on autopsy.

"We did not observe any relationship between the character of the reaction and the lesions. One of our questionable reactions proved to be a well-advanced generalised case. The only case of miliary tuberculosis found on autopsy gave a reaction, a swelling somewhat less than half an inch in diameter. Numerous cases giving a more pronounced reaction than this showed very small insignificant lesions on *post-mortem*."

(2) *Comparison of Intradermal and Subcutaneous Tests without Slaughter.*

"Opportunity was afforded us to apply the intradermal test to a dairy herd of twenty-seven animals seventy-six days after the herd had been subjected to the subcutaneous test. It was possible to compare the results of the two tests on twenty-five animals. There was total agreement in twenty-one cases. Of these, ten were positive and eleven were negative. One animal reacted to the subcutaneous test but not to the intradermal test. Three reacted to the intradermal test that had not reacted to the previous subcutaneous test. This does not necessarily indicate a disagreement, as there is the possibility that infection may have occurred subsequent to the first test. Two reacted to the intradermal test which, on account of the high initial temperatures, were not given the subcutaneous test.

" In making these comparisons we used scrupulous care to exclude any knowledge of the results of the previous subcutaneous test that might influence our judgment in applying the intradermal test. We compared results only after reaching a decision on the intradermal test."

(3) *Comparison of Intradermal and Subcutaneous Tests with Slaughter.*

Ward and Baker are indebted to Dr. C. M. Haring, of the University of California, for opportunity to apply the intradermal test to eight cattle previously tested by him with the subcutaneous method and to check the results by autopsy. The table given shows an agreement in seven of the eight cases, six positive and one negative. One case, No. 4, which did not react to the subcutaneous test, did react to the intradermal, and proved positive on autopsy. This one, of course, might have been infected subsequent to the subcutaneous test.

(4) *Intradermal Test immediately following Subcutaneous Test.*

" Opportunity was afforded to apply the intradermal test to a dairy of twenty-two animals five days after the subcutaneous injection of tuberculin. Four had reacted to the subcutaneous test, but none reacted to the intradermal test. The four reacting animals and one non-reactor were slaughtered. The autopsy proved the accuracy of the subcutaneous test.

" The results point emphatically to the conclusion that a recent subcutaneous test interferes with the intradermal test.

" SUMMARY.

" (1) We have shown that twenty-eight out of thirty reactions regarded by us as positive proved positive on autopsy. Of four considered questionable three proved positive on slaughter. Two diagnosed as positive, showed no lesions. Fifty-nine considered as non-reactors proved negative on autopsy. Seven considered negative reactions showed lesions.

" (2) The determination of a reaction calls for careful discriminating judgment on the part of the operator.

"(3) With regard to the seven cases of tuberculosis which we failed to recognise by the test, we prefer to attribute these to our own inexperience rather than to a failure of the test.

"(4) It is the only test so far known that is applicable to range cattle, on the range.

"(5) In comparing the subcutaneous and intradermal tests we find a remarkably close agreement in results.

"(6) It requires no modification of the ordinary routine of the animals, except that in range cattle it is necessary to confine them while making the injection, and again forty-eight hours later, to make the diagnosis. The time of this confinement is insignificant.

"(7) The intradermal test applied five days after the subcutaneous test is not reliable."

The International Commission on the Control of Bovine Tuberculosis[1] state that "As the newer methods of applying tuberculin for test purposes have not been found to be as reliable as the older, subcutaneous method, they cannot be advocated.

"The ophthalmo and cutaneous tuberculin tests may have a value in some special cases, as, for example, where doubt exists about the reliability of a subcutaneous test because an animal may have been subjected to some pernicious manipulation. In this sense, these later modes of applying tuberculin should be kept in mind."

CURE OF BOVINE TUBERCULOSIS.

Having now discussed the nature and detection of the disease we must devote attention to its suppression, and it would seem natural to inquire "Cannot tuberculosis in bovines be cured?"

In the treatment of human beings we have already seen that considerable success has been achieved principally by the use of tuberculin, and that phthisis, as Newsholme[2] states, is "....an eminently curable disease" if recognised at an early stage.[3]

In relation to bovine tuberculosis, however, Williams and Baldrey[4] state that "If the disease has passed beyond the very earliest stage it is a waste of time and money to treat animals suffering from tubercular consumption."

Mohler and Washburn[5] tell us that up to 1908, the efforts made by the Bureau of Animal Industry in the cure of bovine tuberculosis, by means of sera and attenuated cultures of tubercle bacilli had been unsuccessful.

Iodine therapy

Encouraging results recorded in curative treatment have been achieved by iodine treatment. This powerful therapeutic agent, introduced into medicine over a hundred years ago, is too active

1. Rept. Int. Com. on C. of B. T., p. 22.
2. The Prevention of Tuberculosis, p. 316.
3. The Prevention of Tuberculosis, p. 306.
4. Principles and Practice of Veterinary Medicine, p. 370.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 623.

in its pure, uncombined state for direct internal use, hence certain compounds of it are used which, under the action of the body juices, are split up with the gradual liberation of iodine in the animal economy. Under these conditions the iodine, being, as it were, freshly born (*in statu nascendi*) in minute continuous quantities, is especially efficient.

Iodipin

The suitability of the various compounds of iodine has formed the subject of investigations at different times, but the combination with sesamé oil, introduced by Winternitz[1] and prepared by Merck of Darmstadt, under the registered name of "Iodipin," occupies, apparently, the leading position.

In this form the animal body can tolerate remarkably large amounts of iodine, which are also retained during comparatively long periods.

Iodism

Like many other valuable therapeutic agents or medicines, iodine is a poison ; but without going so far as the poisoning action, certain individuals, both in men and lower animals, exhibit a peculiar susceptibility to it. This susceptibility is evinced in bovines by untoward symptoms, usually taking at the commencement the form of catarrh. The symptoms vary in intensity according to the dose and the susceptibility of the particular subject. Cases are recorded in which death has rapidly followed the administration of what was considered a curative dose. Hence, some discrimination is necessary in the use of so powerful an agent, though the vast majority of individuals tolerate it sufficiently well to allow of its use in a practicable manner.

The phenomena of these so-called side effects of iodine are known as "iodism" and usually accepted as an indication that the treatment must be either modified or discontinued.

Mode of action of iodipin

The compound of iodine and potash has for long occupied a highly important position in therapeutics, but its side effect is rather marked, apparently on account of the ease with which iodine itself separates from it under the action of the body fluids. This is not the case with iodipin, however. Hauptmann refers to the investigations of Winternitz, who has shown that iodine fat is absorbed by the animal economy and laid on as body fat, gradually splitting up and thus permeating the whole system. Winternitz has shown that iodine fat even penetrates the organs which are free from visible fat—the liver and muscles—also the bones.

Klingmuller has shown that after a course of iodipin treatment iodine may be detected in the urine for the succeeding four or six weeks, sometimes quite distinctly after four months.

Feibes confirmed the belief that after injection of iodipin under the skin, iodine is excreted in the saliva, urine, small quantities in fæces, but none in the perspiration. The excreted iodine is not found

1. Münch. Med. Woch., 1903, No. 201; quoted by Heinrich Holterbach, Veterinarian, Berliner Tierärztliche Wochenschrift, 1910, Nos. 41-5.

in combination with fat, hence it is concluded no odipin escapes from the system unused. All the iodine must have been set free at some point, exerted its antiseptic action, and entered into new combination.

That the action of iodipin is not only lasting but prompt is shown by the fact that traces of iodine can usually be detected in the urine the day following the injection of iodipin. The excretion continues very uniformly, attaining a certain maximum which is not exceeded even if excess of iodipin be injected. This maximum is 0·4 gramme per 1,000 grammes urine (0·04 per cent.). Exercise of the body stimulates excretion of the iodine.

Iodine therapy in human beings led Hauptmann[1] to make experiments on the cure of tuberculosis in bovines.

Mode of injection

On account of the syrupy consistency of iodipin, it is necessary to use a syringe with a wide needle tube for its subcutaneous injection, especially when using the 25 per cent. strength. Warming the liquid by placing the bottle in hot water facilitates the process. It is convenient to employ the higher strength (25 per cent.), so as to keep the dose small in bulk. Separate the needle from the body of the syringe. In order to avoid a lung embolism,[2] one first introduces the injection needle into the subcutaneous tissue and waits to see if bleeding occurs. While waiting, the syringe should be filled by an assistant from a wide-necked glass. The full syringe is connected to the needle and slowly injected. Still holding the needle in position, the body of the syringe is removed and handed to the assistant for another charge. With the liberated hand the spot is massaged. In this way one may inject any desired quantity without loss, and with only one puncture, thus minimising uneasiness to the animal. Hauptmann recommends the use of a needle 50 millimetres long and 1·5 millimetre in diameter.

Pains, local inflammation, infiltration, or abscesses, Hauptmann continues, have never been observed. This is due to the fact that iodipin is itself an antiseptic, and, indeed, may be used for the healing of wounds. For the same reason, it is unnecessary to sterilise the syringe before use if it is kept in a clean case, preferably of porcelain.

Hauptmann's experiments

For experimental purposes, Hauptmann selected a byre the animals of which were notoriously infected with tuberculosis. All the animals had been found tubercular on slaughter, some of them so extensively infected that they had to be handed over to the Freibank.

Three well-nourished animals were selected from a number which had been proved tubercular by the tuberculin test, two heifers of

1. Veterinary Physician Emil Hauptmann, Director of the Town Abattoir in Warnsdorf. Tierärztliches Zentralblatt, No. 33, Nov. 20th, 1903.
2. "Embolism"—a term applied to the process by which a thrombus, or clot, undergoes disintegration into minute particles, which are arrested in the capillary circulation; the obstructing plug is termed an embolus..... (Hoblyn.)

fifteen months and two-and-a-half years old respectively, and a nine-year-old cow. (Nos. 1, 2, 3.) The heifers were well developed, and except for a slight cough appeared sound. The cow was in calf. The byre conditions were very good.

Two more heifers (Nos. 4 and 5) were selected from a less favourable byre. These animals were not so well developed as the three before mentioned. Their ages were respectively one and a half and two years. Both reacted typically to tuberculin, but neither showed any signs of illness.

The animals Nos. 1, 2, and 3 were each given three tablespoonsful of 10 per cent. iodipin daily with their food. No unpleasant effects appeared except that No. 2 showed slight loss of appetite. The treatment was, therefore, continued until 1,000 grammes had been taken by each animal.

Two months were then allowed to elapse and the three animals re-tested with tuberculin. All three reacted typically. The experiment was apparently a failure.

Shortly after this, November 22nd, 1901, No. 2 had to be slaughtered for economic reasons. The *post-mortem* findings confirmed the results of the tuberculin test, but the lesions showed signs of healing, and Hauptmann concluded that the failure of the attempted cure was due to insufficient treatment. He therefore turned his attention to subcutaneous injection. It was at this point the two new animals, Nos. 4 and 5, were enlisted for the continuance of the experiment with 25 per cent. iodipin.

Commencing with a daily dose of 10 grammes administered to the cow only, the dose was increased to 50 grammes. No untoward effects were observed, but, on the contrary, the cow's condition improved. The coat of hair became glossy, and the cough, which had lasted for several years, disappeared. When the animal had received 210 grammes iodipin, the owner complained that the yield of milk had declined somewhat; with the green food in the following spring, however, the milk yield rose higher than ever before, so that the owner altered his intention of sending the animal to the butcher.

As 50 grammes for a daily subcutaneous dose had caused no ill effects, Hauptmann considers it should be accepted as a standard for a mature cow, while the experiment with animal No. 4 (a heifer) showed that the same dose injected every alternate day was accompanied by gain in weight.

Forced doses

The experiment with No. 5 was carried out with the view of securing a laying on of iodine fat at opportune intervals, whether the same effect could not be obtained in a shorter time with larger doses. Accordingly, 230 grammes of 25 per cent. iodipin were injected in three days. No ill effects were observed; so five weeks later, a dose of 100 grammes, equal to 25 grammes of iodine, was injected. Still no disadvantage was noted. Hauptmann considers this might justify the conclusion that iodipin is a perfectly harmless medicament.

In the case of animal No. 3, the subcutaneous treatment followed immediately on the internal treatment, while with No. 1, a long pause intervened. Six hundred grammes of the 25 per cent. iodipin were injected into each animal in the subcutaneous series. No. 1 calved during the pause between June 27th and August 3rd without difficulty, danger, or resultant illness.

Some of the experimental animals increased in weight quite considerably, and all were in good condition. All remaining animals were now tested with tuberculin.

No. 1 ..	.. 296	days after the previous test.
No. 3 ..	.. 122	,, ,, ,,
No. 4 ..	.. 66	,, ,, ,,
No. 5 ..	.. 66	,, ,, ,,

The results of the tests were negative, and Hauptmann considered the cure complete.

Holterbach's investigation

Holterbach[1] studied the action of iodine fats cheaper than iodipin, but concluded the latter was well worth the difference in price. He describes the case of a cow to which he was called in the autumn of 1906. The animal was about eight years old, very thin, subject to diarrhœa, and had the paroxysmal cough found in tuberculosis of the lungs. Auscultation revealed râles[2] of a highly varying intensity in the lungs. Tuberculosis had shortly before appeared in the byre. Holterbach diagnosed the case as one of advanced tuberculosis and advised slaughter. The owner insisted that the animal was a good one, however, and as she gave so much milk, demanded treatment. Accordingly Holterbach prescribed a spoonful of 10 per cent. iodipin to be added to the drink morning and evening each day. The animal took the medicine eagerly. After ten days' treatment the general condition began to improve beyond all expectations. At the end of October the animal was fat and " more beautiful than ever before," the cough and râles had disappeared. The former tiredness had given way to a fair vivacity. Only a certain shortness of breath remained, and this caused no disquietude. In short, Holterbach's diagnosis was held in derision. Things remained so until May, 1907. Attacks of shivering fits had been observed, and in spite of good appetite, the animal became emaciated and exceedingly weak. When a slight swelling of the supramammary glands appeared, the people concluded that " the mouse had bitten the cow " and veterinary aid must be sought. On June 9th, 1907, there could be no possible doubt of the correctness of the diagnosis. It was tuberculosis in the final stage. All treatment, including iodipin for a month, proved in vain, so the cow, emaciated to a skeleton, was slaughtered on September 3rd.

1. Berliner Tierärztliche Wochenschrift, 1910, Nos. 41-5.
2. " Râles, rhonchi or rattles "—the bubbling, crackling sounds heard during the passage of air through tubes more or less blocked by secretion or by swollen mucous membrane.—Hoblyn.

Post-mortem examination revealed generalised tuberculosis with fresh miliary tubercles on the pleuro pulmonalis and costalis and liver.

Holterbach's results

Holterbach describes twenty-six cases which he had treated in three years with the cheaper iodine fats. In one, the success was complete ; in nine cases, a lasting improvement was obtained ; in eleven cases, a distinct but only temporary improvement, *i.e.* from a few weeks up to three months—giving way to fatal relapse ; in four cases, marked deterioration and death followed.

A remarkable case

The one remarkable case took the following course. M., a member of the Farmers' Cattle Insurance Society in Z., consulted Holterbach April 22nd, 1908, concerning a cow with the following history. Until a few weeks previously, the animal had been "in the pink" of health and one of the finest in the village. Then, gradually, progressive emaciation became noticeable. Care and attention were unavailing. For three weeks diarrhœa, attacks of coughing, and gradually increased rate of breathing had been observed. Holterbach found the animal free from fever ; rate of breathing when at rest, 30 ; pulse of heart, 70-76. Auscultation of lungs revealed râles on both sides. No swelling of lymph glands discoverable ; appetite very good ; peristaltic action of stomach and bowels, very good though partly rumbling ; fæces thin, somewhat slimy, and of sour, foul odour. Emaciation very marked ; hair dull and rough ; movement tired ; look dim and passionless. When the animal was exercised in the open air, the attacks of coughing became more frequent and of longer duration. No abnormal symptoms discoverable on percussion. These conditions being maintained during ten days' observation, Holterbach diagnosed the case as one of tuberculosis. The result of tuberculin testing confirmed the conclusion. 3 per cent. jodozoniment was prescribed. On the fourth day of treatment slight symptoms of iodine idiosyncrasy appeared, namely, catarrh of mucous membrane of the eye, marked salivation, and loss of appetite. The treatment was not modified, however, and the symptoms disappeared on the sixth day. On the tenth day, the dosage was increased to a tablespoonful of 6 per cent. jodozoniment given three times a day with the bran mash. Total quantity of iodine fat consumed, 1,200 cubic centimetres (cost, according to price current of Bengen, about 7s.).

Course of the disease : From October 8th distinct improvement, the cough became much better, breathing quieter, the rattling sounds on auscultation became much weaker and only heard in the middle third. The movement became more active, the look more attentive, and, what was more noticeable, the hair became smooth. The improvement continued steadily and the emaciation disappeared. In the middle of November, the following findings were noted : General health very good, nutrition excellent. The cow was not as fat as said to have been, but, apart from this, quite on a par with the remaining cows in the stable ; movement smart, strong, and vivacious ; cough not heard since the beginning of November, not even during or after prolonged exertion. Diarrhœa, which at the beginning of the iodine treatment had become worse, now disappeared. Peristaltic action on both sides normal. Auscultation of the lungs gave at every point normal vesicular breathing. The patient is now, with necessary caution, of course, used for light work. "I have seen her," Holterbach states, "up to June, 1909, almost daily, and examined her every fourteen days. The cure remained permanent. One could practically call her fat. She worked in the summer of 1909 satisfactorily like the other cows of the owner. The condition remained thus up to December, when I examined her for the last time, and felt satisfied that the cure had resulted from iodine treatment."

In discussing iodine treatment for other diseases, Holterbach is clear that he observed no injurious effects even in respect of the breeding capabilities of bulls.

"Tuberculosan Burow"

Still better results appear to have been secured by Dr. Burow[1] with his preparation "Tuberculosan Burow," which consists of the toxins of the bacteria of hemorrhagic septicæmia.

Burow was led to the study of bovine tuberculosis by his experiments repeating the work of Römer, Gärtner, and Buchner on the reaction in tuberculous cattle to bacterial extracts other than true tuberculin, preparation of these extracts and their influence on the lymph stream.

Turning his attention to tuberculous cattle, he soon found that his preparation from the bacteria of hemorrhagic septicæmia produced prompt mitigation of the clinical symptoms of tuberculosis.

Burow believes that the destructive action of the disease is mainly due to the toxin of the tubercle bacilli, and that in attacking it one is striking at the immediate cause. The body itself will deal with the organisms if it can simply be provided with a little respite from the poisonous action of the tubercle toxin. The ultimate success of the cure will depend upon the amount of vitality left, the extent of the damage the body has already suffered, and the quantity and virulence of the poison to be dealt with. Tuberculosan appears in some way to neutralise the tubercle toxin.

Burow points out that the main result of sanatoria treatment of human tuberculosis is the fortification of the body to overpower the toxin,[2] and that if this toxin can be quickly arrested much time is gained. Tuberculosan has been applied in human treatment with favourable results, which Burow will state after further experience, but for the present these good results are simply adduced in support of the method as applied to bovines.

1. Berliner Tierärztliche Wochenschrift, Jahrgang 27, 1911, No. 36, p. 637 *et seq.*
2. Dr. Nathan Raw agrees that the improvement resulting from open-air treatment is due to increased nutrition—possibly an artificial gouty condition. See The Clinical Journal, Aug. 23rd, 1911, p. 318.

In the human practice the improvements observed following the treatment were similar to those noted in bovines, *i.e.* suppression of fever, abatement and sometimes sudden disappearance of night sweats, increased appetite, better general health, increase in weight, diminution of cough, and retrogression of local symptoms.

Symptoms of improvement, Burow claims, are symptoms of cure.

After finding marked differences in individual susceptibility (in rare cases reaction has been produced) Burow has arrived at a gradual dosage which never produces harmful results either in healthy or tuberculous individuals, and shows distinct improvement in ordinary cases and a little even in otherwise hopeless cases.

The proof of the neutralising power of Tuberculosan depends upon the effects observed in the animal economy. Direct experimental proof is lacking. Thus Tuberculosan will not prevent a tuberculous animal reacting to tuberculin. In explanation of this Burow maintains that the natural tuberculin produced in the animal body in the course of the disease is not the same as artificially produced tuberculin. The dose of Tuberculosan for a mature animal is 10 c.c., and costs about one shilling and sixpence.

Returning to our discussion of the disease in lower animals, Dr. Burow at the outset draws a sharp distinction between cases in the early stages and advanced cases. The former he claims to cure, and in the advanced cases, although cure he admits is impossible, a sufficient improvement is obtained to make it well worth while from a commercial point of view.

He has mainly kept tuberculosis of the lungs in view, and confined his attention to cases of natural infection occurring in practice rather than to experimental or laboratory animals. The results are attested and confirmed by the independent veterinary surgeons who had the cases in hand.

Definition of Mild Case.—Animals which formerly were in good condition and showed no signs of illness show a failure of appetite and resultant distinct emaciation, increased temperature, and decreased yield of milk. The hair loses its gloss and becomes rough. The skin becomes hard and adheres to the underlying tissues, especially over the ribs. The eyes are dull and the back humped. The animals present the picture of cachexy. The cough characteristic of tuberculosis of the lungs is not always present. Reaction to tuberculin is almost invariably strongly marked.

The majority of such animals treated by Burow were young.

Results for Mild Cases.—After subcutaneous injection of Tuberculosan Burow, the appetite, condition, and fettle almost immediately improved, and the yield of milk increased considerably in almost every case. These improvements were distinctly visible in a few days. Ten days after injection the skin became softer, shiny, and less adherent. The hunchback appearance, when present, disappeared, and the whole tendency improved towards complete recovery in two to three months. The cough, when present, became looser, less frequent, and disappeared after a few weeks.

In those cases in which a second vaccination was performed two to three weeks after the first the recovery was still more rapid.

The reality of the cures have been proved by *post-mortem* and histological examinations, the tuberculous areas being found strongly encapsulated with newly-formed fibrous tissue, and even the most recent tubercles calcified.

Advanced Cases of Tuberculosis.—These are usually characterised by extreme emaciation. The skin is hard, difficult to raise, and lies in folds. Often a crackling sound is heard on endeavouring to raise it. The symptoms described for the less advanced cases are here accentuated, and in the case of lung tuberculosis the breathing is laboured and the stethoscope reveals rattling and grating sounds in the lungs. Animals in this advanced stage frequently do not react to tuberculin. Burow considers them not only valueless, but a standing menace to their companions.

Results with Advanced Cases. — Provided the disease is not generalised, this investigator claims that such animals can, in the course of a few weeks, be so much improved that they, at any rate, become of value either for slaughter, milk production, or for other farm purposes. Cure, as already stated, he considers impossible, but in a large proportion of the cases a useful degree of recovery, evidenced by increase in weight and improvement of general condition, is claimed.

The involvements of the organism are so deep seated, extensive, and complicated in advanced cases that Burow cannot positively state that *post-mortem* or histological examination afforded proof of recovery. Much more detailed work will be necessary to decide these far-reaching questions. All that this investigator claims is that he has put animals so far gone as to be only fit for the knacker back on their feet in a few weeks to three months by means of two or three injections of Tuberculosan, and without alterations in the food or care, so that they became of some use.

Naturally it is recommended that animals under treatment, therefore infected, should be isolated from healthy animals.

Burow has received reports of Tuberculosan treatment from sixty-two veterinarians of all degrees—fifty-eight of these are favourable, while four found no benefit. Some of the latter unfavourable reports are by eminent authorities, and are stated very fully by Burow. The reports relate to 1,200 vaccinations on 208 cows. We have been in communication with one of the above-mentioned veterinarians. He now endorses Burow's claims with enthusiasm, although originally very sceptical.

ERADICATION OF BOVINE TUBERCULOSIS BY SLAUGHTER.

Writing concerning American conditions, Salmon[1] says: "The objection to the Bang system (see p. 286) and to all modifications of it is the length of time that tuberculous animals must be kept on the premises, injuring the reputation of the herd and causing much extra work in caring for two herds, sterilising milk, and taking precautions to prevent infection of the healthy animals.

Advantages of slaughter

"It is true that the prescribed precautions are not always carried out, and equally true that in such cases there is usually not very marked success in getting rid of the disease. For this reason, it has been considered best, where the cattle have no special value for breeding purposes, to slaughter reacting animals, and disinfect the stable and thus immediately stamp out the disease. Most dairymen prefer this plan as the more economical of the two. The eradication of tuberculosis from the herd of the Maine Agricultural College is a valuable example of what may be done by this plan."

"We frequently hear," says Reynolds,[2] "intelligent people say that all this tuberculosis work is wrong. They say: 'You must test all the cattle in the State and eradicate the disease, and that is the only business-like thing to do.' Sweeping plans have been proposed for eradication; but those who propose them do not appear to have had a close view of the great difficulties in the way of actually carrying out such propositions."

Cost of tuberculin testing

Reynolds has calculated the cost, and his figures may well be commended to the consideration of legislators and hygienic extremists. We shall give a short abstract of the estimate for the State of Minnesota, containing about three million cattle, worth about $50,000,000. Two per cent. of these are pure bred. Total number of dairy cows over two years of age, 590,728. The calculation is based on the following standards:—

Testing all cattle in the State twice a year for two years and annually for the next five years; stable disinfection after each test; reimbursement to owners of one-half appraisal—owner to receive, in addition, the carcass salvage.

Estimated total cost $35,004,260, or a little over seven million pounds sterling. In Great Britain we have about seven million cattle, worth considerably more per head than cattle in Minnesota; but on account of the greater concentration, the testing could be done much cheaper per head than in Minnesota.

Reynolds feels they are in a much worse plight in Minnesota, of which "The total annual expenditures for all purposes by this State amount to about six and a half million dollars"; so that eradication work on this basis during the first year would require considerably more than the entire available resources of the State that year Can

1. B. A. I., Bull. 38, p. 89.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 940.

there be any question concerning the hopeless impossibility of rapid eradication under present conditions and with present available agencies ? Nor may we reasonably expect complete eradication in the near future. But if absolute eradication, which would be ideal, is unattainable, is it not the part of wisdom to content ourselves with the best work that may be within the limits of reasonable possibilities ? "[1]

Eradication attempted in Holland.

On the advice of the distinguished pathologist Nocard, eradication of bovine tuberculosis by slaughter of reacting animals was attempted in Holland in 1895.

It was demanded, says Bang,[2] ". . . . that the reacting animals should be slaughtered within a year, and that their milk should be used only when boiled ; but it was soon found necessary to rescind the order."

Britain

Regarding the proposal that in our own country only tested cows should be kept for milch purposes, M'Fadyean[3] says, " I doubt whether any one who is well acquainted with the circumstances of the case now believes this practicable. . . . . the fact that one-third of the cows now giving milk are tuberculous is an insurmountable obstacle. The cost of carrying out the tuberculin test several times annually in all the milking herds in this country would be enormous, and the exclusion of all reacting cows from such herds would seriously disorganise cattle breeding as well as milk production. Moreover, to rely blindly on the tuberculin test, and to pronounce the milk of every cow that does not react to it free from tubercle bacilli, would be very unsafe. The test is recognised to be one of great value, but it is not infallible."

[4]". . . . To urge that the disease should be attacked on the lines adopted in dealing with cattle plague and pleuro-pneumonia is an effectual method of preventing any Government from touching the subject."

The eradication of bovine tuberculosis by slaughter of all reacting animals does not commend itself on account of the large number of cases in which the disease resolves into a harmless quiescent state. Early in his experience on the subject, Bang[5] found that ". . . . the great majority of reacting animals suffered only from a very limited, often quite insignificant, form of tuberculosis, and by observing the fate of such animals (after slaughter), it was seen that in many of them the disease did not develop farther, but, on the contrary, tended to decrease." As we shall see later, Bang mentions that in some cases cure takes place.

Cannot rely upon recovery

Regarding recovery, Russell and Hastings[6] state : " Some animals

1. 6th I. C. on T., Vol. 4, pt. 2, p. 944.
2. 6th I. C. on T., Special Vol., p. 212.
3. Trans. B. C. on T., Vol. 1, p. 86.
4. Trans. B. C. on T., Vol. 1, p. 85.
5. 6th I. C. on T., Special Vol., pp. 211-12.
6. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 22.

react once, but not on subsequent tests. If failure to react depends upon the disease becoming dormant, such a condition might be taken to indicate recovery, but so little is known concerning this condition that it is not advisable to take possible recovery into account in the handling of tubercular animals."

The International Commission on the Control of Bovine Tuberculosis[1] state " It was felt, in view of the prevalence of the disease, especially in some localities and among certain classes of cattle, the difficulty of providing a sufficient number of trained officials and the large economic questions involved, to say nothing of the enormous expenditure, that it would be unwise, for the present at least, to seriously discuss a policy of universal compulsory testing and slaughter. Such a policy might perhaps be adopted with advantage by a small community or one in which the disease existed to a very limited extent ; but, speaking generally, especially in view of past experiences in this line, it was thought better to omit it entirely from the recommendations of the Commission."

MILK SUPPLY FROM TUBERCULIN-TESTED CATTLE.

Tuberculin test ordinances United States

Notwithstanding the difficulties of the problem, a serious effort is being made by a number of American cities to eradicate tuberculosis in all herds supplying milk to them. The regulations for sale of milk (milk ordinances) are generally framed on the following lines : —

Milk may only be sold under annual licence.

The Board of Health have jurisdiction to refuse a licence, and are usually guided by the Health Commissioner who actually issues the licence. Cows supplying milk to the cities must be free from tuberculosis as proved by clinical examination and tuberculin test. Owners are indemnified for reactors on slaughter.

No regulations are laid down as to the mode of disposal of the tuberculous cow ; but from the correspondence we have had with the Health Commissioners of these cities, it appears they insist on slaughter, otherwise suspend or cancel the licence. This is an interesting instance of official discretionary power.

Ward,[2] 1909, quotes the list of the cities which had adopted the tuberculin test ordinance as given in the Minnesota exhibit at the International Congress on Tuberculosis, Washington, 1908. The names of eleven cities are given. Writing in the same year, Eastwood says, " Fourteen[3] cities have adopted a regulation requiring that cows supplying milk shall be tuberculin tested. These regulations affect 25 per cent. of the people in the State. Population of Wisconsin in 1900 = 2,069,042 ; population of the cities requiring the test = 523,302."

1. Rept. Int. Com. on C. of B. T., p. 8.
2. Pure Milk and the Public Health, p. 73.
3. In Wisconsin alone.

In a letter from the distinguished Chief of the Bureau of Animal Industry, under date of March 18th, 1910, he gives us the number of cities as ninety-six, distributed in thirty States, thus proving that the movement is spreading rapidly.

In one of the cities the ordinance is not enforced, and in another the alternative of Pasteurisation is allowed.

The clause in the ordinance of the City of Minneapolis, which requires the application of the tuberculin test, dates from 1895. "Shortly after its institution," says Eastwood,[1] "the legality of the clause was disputed, but its validity was maintained by the Supreme Court of the State of Minnesota in 1896."

Canada

It is interesting to note that according to Elliott[2] the principle of compulsory tuberculin testing of all herds supplying city milk has been adopted by the following Canadian cities: Quebec, Moncton (N.B.), Portage, La Prairie, and Manitoba.

Dumping tuberculous cattle

Dumping Tuberculous Cattle.—An important sequel of localised efforts directed towards the extirpation of tuberculosis in milch cows arises from the transference of the condemned animals into neighbouring areas where, as Dr. A. G. Anderson[3] expresses it, ". . . . the health authorities are more quiescent and tolerant of bovine tuberculosis. Hence it comes to pass that the inhabitants of the latter district may not only suffer through the dissemination of tuberculosis by tubercular milk from cows within their own district, but such a district becomes a sort of dumping ground for tubercular cows, whose number is continually augmented by transference of such cows from their more active and contiguous neighbours."

Speaking at the meeting of the Yorkshire Federation of Dairy Farmers' Association, held at Leeds on April 11th, 1911, Mr. S. W. Hackney,[4] the chairman, said that "At the present time local authorities are enforcing their powers with regard to cows supposed to be suffering from tuberculosis of the udder. This entails considerable expense to the ratepayer. Moreover, the inspections are far from satisfactory, because a diseased animal can be sold and removed into another district, and probably come under the inspection of another local authority at a further expense to the ratepayer, and little benefit accrues from it, because the diseased animal can be removed at any time by the owner and sold into another district. We maintain that if these diseased animals were slaughtered at the first time of inspection, and their owners compensated, it would be an immense saving to local authorities, and the diseased animals would be finished with once for all. We hear of prompt measures being taken where foot-and-mouth disease breaks out, but no legislation where tuberculosis is concerned."

1. Dr. Eastwood's Rept., p. 45.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 140.
3. Dr. Anderson's Rept., p. 34.
4. See The Farmer and Stockbreeder, April 17th, 1911, p. 734.

REINSTATEMENT OF BOVINE TUBERCULOSIS BY HUMAN INFECTION.

Concerning Smith's[1] statement that if either the human or the bovine bacillus were completely eradicated from the world, the other would continue to induce the disease (see p. 46), in case this might be interpreted by some to indicate the futility of attempting to suppress bovine tuberculosis while the human disease exists we may remark that it is hardly probable that any community, after having suppressed the disease in their cattle, would permit reinfection in this manner. Salmon[2] admits that "The tuberculous human being, in the rare cases in which he excretes tubercle bacilli of the *typus bovinus*, presents danger to cattle." He also agrees, however, that [3]"The tuberculosis of human beings, as a rule, is not communicable to cattle, but is communicable to pigs, dogs, and cats."

Is bovine tuberculosis dependent upon human tuberculosis?

At the Sixth International Congress on Tuberculosis, Koch[4] pointed out that the British Commission, which is engaged in the investigation of the relation between human and bovine tuberculosis, has conducted experiments on the feeding of phthisical sputum to cattle. Three calves were fed over a period of one hundred and twenty days, during which time each received a total of 30 litres of sputum. A fourth calf received 21 litres in ninety-one days. After slaughter there were found in these animals isolated calcified nodules, but no traces of the progressive lesions so characteristic of bovine tuberculosis.

On the other hand, a cow was fed with sputum for two hundred and nine days. When the animal was killed at the end of this time a progressive tuberculous process was found in the mesenteric and portal glands. Here there appeared to be a positive result of the feeding experiment. However, in simultaneous experiments, in one of which a cow was fed the same sputum for three hundred days, and in the other two pigs, negative results were obtained.

Koch considered the positive result above mentioned to be an experimental error in that the infection had not resulted from the sputum. However this may be, the experiments demonstrate that infection by feeding is difficult, seeing that the remaining results were negative.

Bang, as we shall see (p. 300), contemplated a remote possibility that the few Jersey cattle found tuberculous when imported into Denmark might have been infected from human sources, but considering "....the fact that in no instance has a culture been isolated (by the English or German Commissions) directly from cattle, showing the characteristics of the human type, the question of possible infection

1. Quoted by Dr. Sherman D. Bonney, Pulmonary Tuberculosis and its Complications, p. 34.
2. B. A. I., Bull. 38, p. 77.
3. B. A. I., Bull. 38, p. 78.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 647.

by cattle from man under natural conditions is," according to Park and Krumwiede, Junr.,[1] "practically settled."[2]

The British Royal Commission[3] state that "The goat and the pig are not, to any great extent, affected by the human tubercle bacillus," and "The cat is resistant to the human tubercle bacillus when this is given subcutaneously, intraperitoneally, intramuscularly, or by feeding."

[4]"Cattle, pigs, and fowls.... are practically immune when the bacilli are administered, even in large amounts with their food."

Bang[5] considers that ".... infection from human beings plays only a very subordinate part in bovine tuberculosis." The cattle in Jersey, many regions of Norway, and other countries remain free from the disease, although the human disease is not very rare.

The experiments of the Imperial German Commission show that infection of bovines with human bacilli is very difficult.

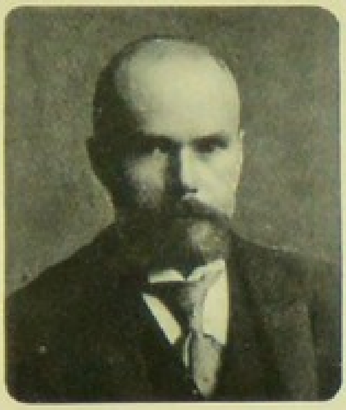
THE BANG METHOD FOR THE SUPPRESSION OF TUBERCULOSIS.

Although the eradication of tuberculosis in bovines by slaughter of affected cattle is evidently progressing in the United States (see p. 284), there seems no probability of its being adopted in older countries. It is too expensive for conservative peoples, and however desirable it may be it has not been demonstrated to be either necessary or as having yielded adequate return.

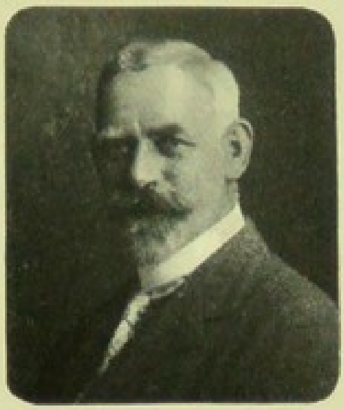
It is obvious that its spread can be checked by the methods of isolation adopted in the case of human disease. Prevent transmission and the disease will die out. This is the essence of the famous Bang method, which in its present form was first enunciated by Bang,[6] in Paris, 1898, and which, on account of its importance, we shall give in the words of the distinguished investigator in his address at the Sixth International Congress at Washington, 1908.

1. Collected Studies from the Research Laboratory, Department of Health, City of New York, Vol. 5, p. 87.
2. The British Royal Commissioners found the human bacillus to be the cause of tuberculosis in a gnu, an antelope, a rhesus monkey, a chimpanzee, and a cat. All had been kept in captivity, however. (Final Rept., p. 24)
3. Final Rept., p. 7.
4. Final Rept., p. 37.
5. 6th I. C. on T., Special Vol., p. 217.
6. Semaine Médicale, Aug. 3rd, 1898.

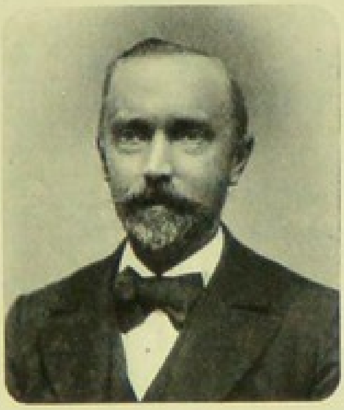
FIVE EMINENT VETERINARIANS OF THE DANISH SCHOOL.



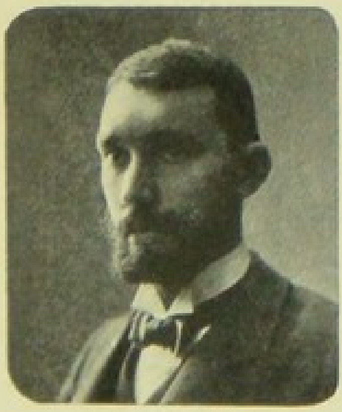
DR. PHIL. ORLA JENSEN
Professor of Microbiology Danish Technical High School, Copenhagen.



P. AUG. MÖRKEBERG
Consulting State Veterinarian, Denmark.



BERNHARD BANG, M.D.
Chief State Veterinarian, Denmark; Principal and Professor of the Royal Danish Veterinary and Agricultural College.



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MEASURES AGAINST ANIMAL TUBERCULOSIS IN DENMARK.

By Bernhard Bang, M.D.[1]

Professor of Pathology and Therapeutics, Royal Veterinary School, Copenhagen, Delegate of the Danish Government to the Sixth International Congress on Tuberculosis, Washington, 1908.

Measures against tuberculosis among domestic animals were first taken by the State by Act of April 14th, 1893, relating to the prevention of infectious diseases among domestic animals. According to Sect. 11 of the Act cattle owners are prohibited :

(*a*) From sending animals (cattle and pigs) that obviously suffer from tuberculosis, to fairs and cattle shows, to common pastures, stables, etc., of other cattle owners, as well as from selling such animals, except for slaughter ;

(*b*) From selling or using as human food animals, or any part of an animal, obviously suffering from tuberculosis, unless a veterinary surgeon's certificate be produced stating that a previous examination of the carcass and the entrails has shown the meat to be fit for human consumption ;

(*c*) From selling the milk of cows suffering from tuberculosis of the udder, or using it as human food, or in the preparation of food, or as food for animals, except when boiled.

These measures have, however, produced few practical results. It is true that a number of animals have been rejected when presented for admittance at fairs and common pastures or for exportation, and no doubt the sale of such animals for other than killing purposes has now and then been prevented ; still, it is difficult to impose fines in such cases, the term " obviously tuberculous " being too vague. Paragraphs (*b*) and (*c*) were amended later so as to provide more fully for the cases mentioned in them.

By the Act of April 14th, 1893, relating to State help toward the combating of tuberculosis among cattle, an attempt was made to encourage cattle farmers to take measures to get rid of tuberculosis among their stock. By this Act a sum of 50,000 kr.[2] yearly (afterwards increased to 100,000 kr.) was, for a term of five years, placed at the disposal of the Ministry of Agriculture to pay for gratis distribution of tuberculin, for the injection of this substance by veterinary surgeons, for measuring the temperature of the animals, and for giving directions as to isolation, if the farmer in question wished to apply the tuberculin test to ascertain which of his animals were infected with tuberculosis, but only on condition of his binding himself to keep the healthy animals safely isolated from those suffering from tuberculosis.

As the primary object of these measures was to promote the breeding of healthy young cattle, at first only young animals were tested gratis ; soon, however, the test was also applied gratis in the

1. 6th I. C. on T., Vol. 4, pt. 2, p. 850.

2. 1 kr. (krone) = 100 ø (øre) = about 25 cents (about 1s.).

case of full-grown animals, and gradually it became quite common to subject the whole stock of a farm to the tuberculin test in order to make it possible to isolate the healthy among the full-grown animals.

The passing of this Act was chiefly due to a proposal of B. Bang, who, for some years past, had been studying the efficacy of tuberculin for proving the existence of tuberculosis among cattle and other domestic animals, and who had worked out a system for the extermination of tuberculosis in an infected stock by thorough isolation of the animals that were not yet attacked and by preventing the transmission of infection through raw milk.

According to Bang, tuberculosis is a purely contagious disease. It is true that infection may take place in the uterus so that the calf is born tuberculous, but this happens very rarely—practically only when the cow is highly tuberculous. Most calves are born healthy, even if born of somewhat tuberculous cows, and they will remain so if they are only preserved from infection. In the first place, tubercle bacilli are not ubiquitous. They are mostly found in stables where tuberculous animals discharging tubercle bacilli are, or have lately been, stabled. Secondly, raw milk very often transmits infection, mostly, it is true, when the udder of the cow is attacked, but also frequently when this is not the case; partly because tubercle bacilli may be excreted through an apparently healthy udder, if the cow is highly tuberculous, partly because pure milk may be fouled by the introduction of tubercle bacilli through flux of the uterus or by particles of the fæces of highly tuberculous cows.

The tuberculin tests proved that a great number of cattle of all the herds among which tuberculosis had long been prevalent were infected with this disease. *Post-mortem* examinations proved, however, that most of the reacting animals were only slightly affected; in many cases only small caseous-calcareous deposits were found in a few of the lymphatic glands, processes that no doubt often remain unchanged for years or are even sometimes cured.

According to Bang, therefore, there was no reason to kill milch cows that did not show clinical signs of tuberculosis but only reaction to tuberculin. So long as they were stabled in isolated stables, there was no reason why they should be killed or why their milk should not be used and calves bred from them, provided the latter were as soon as possible removed from the infected stable and were not infected by being fed on the raw milk of tuberculous animals.

The highly tuberculous animals should not, of course, be allowed to form part of the stock, but should be killed as soon as possible—a measure which had certainly been taken rather often in former times, though not nearly as often as circumstances demanded.

It will be seen that these measures—devised by Bang and founded on the above facts—for combating tuberculosis among cattle interfered as little as possible with the breeding. He wanted farmers to remove from their stock only such animals as, from reasons of general economy, they would feel inclined to remove, *i.e.* the animals that a merely clinical examination proved to be tuberculous. They were allowed to keep those that did not appear tuberculous until subjected to the tuberculin test, as long as they found they yielded sufficient milk, and to breed their calves, if only they took good care to keep the latter isolated from the perfectly healthy animals. If the isolation could not be carried out in any safer way (which would, of course, be preferable), a part of the stable might be partitioned off by a wooden partition, reaching from the ceiling to the floor The common water-pipe would have to be cut off, or, if this was not practicable, it might be sufficient to let the water pass first through the part of the stable reserved for the healthy animals. If absolutely necessary, it would be permissible to have tight-fitting doors in the partition wall ; though this has certainly often proved a drawback, it being, of course, very difficult to keep such doors shut when not in actual use.

Whenever it is at all possible, as it would be in the case of a large stock, there ought to be two sets of stable hands—one for the healthy animals and one for the infected ones. If this was not possible, the servants would have to tend and milk the healthy animals first and have two sets of boots or shoes and overalls, as well as of implements, one for each class of animal. In the pastures the two divisions would also have to be kept apart as much as possible, though the danger is considered to be less when the animals are grazing than when they are in the stable.

As from the very outset it was quite clear to Bang that isolation of the animals on the same farm, especially if such had to be effected in one building by means of a partition wall, could not be a complete guarantee against the introduction of contagious matter among the healthy animals, and that the tuberculin test was not in every case quite infallible (for instance, the animals might have been infected just before the test and so be unable to react), he directed that the healthy division was to be subjected to the tuberculin test once—or preferably twice—a year, so that those animals which, in spite of the isolation, proved to be infected, might be removed without delay from the healthy division to the reacting one ; his object being the gradual purification of an infected stock during the course of several years. It would thus become possible for a farmer possessing a stock in itself valuable, though infected with tuberculosis, to gradually convert it into a healthy one by breeding from his own stock.

As early as 1892 Bang was enabled by a special Government grant to demonstrate the practicability of his theories by gradually changing a highly tuberculous stock into a healthy one. The farm of Thurebylille was selected for this experiment. On the first application of the test 131 animals reacted, while only 77, mostly young animals, were found to be healthy. Of the milch cows, 80 per cent. reacted, and of the young cattle and calves, only 40 per cent. The isolation of the two classes, the reacting and the healthy ones, from each other was effected by partitioning off a part of the stable with a solid wooden partition, the shed occupied by the calves forming part of the healthy division. There were two sets of stable hands, one for each of the two divisions, which were, moreover, kept apart when grazing as well as in the stable.

The practicability of the plan was soon proved, as the calves which were born in the infected division of reacting parents were nearly all found to be healthy (very few being born tuberculous), and remained so, provided they were at once removed from the infected stable and fed on boiled milk, their mother's milk (raw) only being given to them on the first day.[1]

Still, as had been expected, year by year some of the animals of the healthy division did not pass the half-yearly test; in other words, some infection was introduced into the healthy division in spite of the isolation. Generally, it was only one or a few per cent. that did not pass the test; on a few occasions, however, it was as much as 9 per cent. It will thus be seen that the elimination of the infection proceeded rather slowly; but, then, circumstances were rather unfavourable, because the isolation was not a thorough one, the daily control less effective than might have been desired, and, lastly, because the farmer was not sufficiently alive to the importance of removing highly tuberculous animals, discharging great quantities of bacilli, from the reacting division.

In spite of these drawbacks the healthy division increased year by year, and at last the task of eliminating the disease was successfully accomplished by selling the remainder of the reacting division—about thirty head of cattle. The farm is now one of those that supply Copenhagen with "milk for infants" (*i.e.* superior milk); the stock is every year subjected to the tuberculin test, and the last time, in 1907, not one out of 211 animals reacted.

As the Act of 1893 provided generous assistance to such cattle farmers as were anxious to improve the sanitary conditions of their stock by employing the method which had been tried at Thurebylille, a great number of both small and large farmers set to work, in many cases with excellent results. At all large farms, however, where tuberculosis is generally very prevalent, the elimination of infection progressed slowly, just as had been the case at Thurebylille; a few of the animals of the healthy division reacting whenever they were subjected to the test a second time. The stricter the isolation, the better the results; the best results being, of course, achieved when it was possible to remove the healthy animals to another farm.

The thorough disinfection of stables where highly tuberculous animals had been stabled, in order to destroy all contagious matter,

1. Russell and Hastings state that it is usually wise to allow them to suck their dams once or twice (Wis. Agri. Exp. Sta. Cir. of Information, No. 23, p. 23).

often proved a very difficult task, especially in buildings where the woodwork and the stone floors were old and dilapidated. Where tuberculosis was not very prevalent, as was very often the case among small herds, and sometimes even among large ones (in one case, for instance, only six animals out of 134 reacted), it was, of course, easy enough to root out the infection completely.

By means of the numerous tuberculin tests which—especially during the first few years after the introduction of Bang's method—were applied to cattle in all parts of Denmark, much valuable information was obtained as to the extent of tuberculosis in Denmark, closely corresponding with the results obtained in all other countries where tuberculin was largely used. In many herds the disease was very prevalent. Among large herds (*i.e.* herds numbering fifty or more animals) only few proved to be quite free from tuberculosis. Among stocks of this size the average number of reacting animals was 50 or 60 per cent., while among small herds (numbering less than fifty animals) a great number, about one-fourth, were perfectly healthy, and the number of reacting animals in infected "small" stocks was considerably less than that of the large ones—hardly 30 per cent.

The fact that a great many small stocks consist of none but healthy animals (in 1898 there were 2,203 stocks, numbering 30,101 animals, on an average 14 in each) clearly shows that the opinion prevalent among many medical men that tubercle bacilli are ubiquitous[1] is fallacious. They are never found except in places where animals (or human beings) discharging tubercle bacilli live or have lately lived. Tuberculosis is a purely contagious disease.

The view is strikingly confirmed by a closer examination of herds among which tuberculosis is found. Only such herds are perfectly healthy as are kept up by breeding, receiving hardly any increase from outside, except a calf now and then; while the prevalence of tuberculosis is generally the greater the more frequently the stock is increased by buying cattle at fairs; and consequently the most infected parts of the country are those where a brisk trade in cattle is being done and where buying and selling of cattle is common.

Another way by which infection may be introduced among hitherto healthy stocks is by feeding calves on skimmed milk from a co-operative dairy, among whose suppliers will always be found owners of tuberculous cattle. In cases where the infection had been introduced through the milk the cows were very often healthy, while it was the calves or the young cattle that reacted; sometimes the peculiar fact might be observed that only animals of the same age—for instance, yearlings or two-year-olds—reacted; and when this happened, the heating apparatus of the dairy was found to have been out of order just at the time when milk was supplied to the set of animals that had reacted.

1. "Ubiquitous"—existing everywhere.

In all other cases the tuberculin test proved conclusively that tuberculosis is more prevalent among old than among young cattle. A close examination of 40,624 head of cattle which, during the years of 1898-1904, were subjected to the tuberculin test for the first time, showed that of calves under six months 12·1 per cent. reacted ; of yearlings (from six to eighteen months), 27·5 per cent. ; of two-year-olds (from one and one half to two and one half), 38·6 per cent. ; of full-grown animals (from two and one half to five), 44·9 per cent. ; and of animals over five years old, 48 per cent.—figures which correspond with the results of tuberculin tests in other countries, as well as with the experiences of slaughter-houses and with the results of the study of human tuberculosis.

The method, recommended by Bang, for enabling cattle farmers to combat tuberculosis by their own efforts, *i.e.* strict isolation of the healthy animals and feeding calves on uninfected milk (milk of perfectly healthy animals, or milk heated to 85° C.—now only 80° C.)[1] had at first many enthusiastic followers, as will be seen by the following table :—

	Stocks		Number of Animals Tested		Percentage of Reacting Animals.
	Total Number.	Number of Stocks Tested First Time.	Total Number.	Of these Reacted.	
April, 1893—June, 1894	327	327	8,401	3,362	40·0
June, 1894—October, 1895	1,873	1,645	44,902	17,303	38·5
October, 1895—May, 1896	930	749	20,791	6,622	31·9
May, 1896—June, 1897	7,316	3,012	84,897	21,668	25·5
June, 1897—May, 1898		2,165	65,788	15,642	23·8
May, 1898—January, 1899	1,454	618	35,533	7,725	21·7
1899	1,293	543	33,568	6,759	20·1
1900	1,101	417	26,078	4,976	18·0
1901	695	259	18,818	2,857	15·2
1902	895	396	23,347	3,531	15·1
1903	646	213	19,364	2,875	14·8
1904	738	277	23,164	3,750	16·2
1905	705	221	24,161	3,370	13·9
1906	689	294	25,035	3,398	13·6
1907	580	232	22,982	2,252	9·8

After a few years, however, there was a sad falling off. The carrying out of the above measures demands great vigilance and perseverance on the part of farmers as well as on that of their servants, qualities not often met with. The importance of strict isolation was not at first fully realised by all, the watchfulness was often relaxed, the disinfection of the stables was not always as thorough as it should have been, the milk was not always sufficiently heated. Many farmers

1. 85° C. = 185° F. ; 80° C. = 176° F.

thought the method too troublesome in the long run. If accidents happened, so that too many animals of the healthy division reacted on the repetition of the test, the farmer would lose courage and listen to the many voices (especially those of butchers and cattle dealers) eager to assure him that the tuberculin test was mere humbug. The serious misuse of tuberculin in employing it for the immunisation of cattle intended for export to Germany for killing purposes—these animals, according to the peculiar German regulations, are to be subjected to the tuberculin test in passing quarantine at the German frontier—contributed greatly to the dissemination of wrong ideas among the public. The well-known and unfortunate circumstance that highly tuberculous and consequently infectious animals sometimes do not react at all, or only very slightly, must also be taken into account, veterinary surgeons sometimes neglecting to subject the non-reacting animals to a sufficiently careful clinical examination; so that it sometimes happened that a specially infectious animal was placed among the healthy ones.

However, although there was a great falling off, many farmers have persevered, and most of them—both owners of large and of small stocks—have obtained excellent results. For instance, on the first application of the test in 1894, at the farm of Borupgaard, in Jutland, 139 out of the total number (82 per cent. of the full-grown animals) reacted, and only 86 were found to be healthy. When the test was applied at the same farm in 1908, out of 245 animals only one calf reacted, and so slightly that the reaction must be considered doubtful. This excellent result had been attained by strict isolation (division of a large stable by a wooden partition and separate stables for calves and young cattle). According to the careful calculations of the owner of the farm, the total expense of the isolation was about 1,000 kr.

When the test was first applied in 1896 at Count Wedell's estate, Wedellsborg (Funen), 166 of the animals reacted, and only 74 were found to be healthy. Now there is a stock of 264 head of cattle, of which only three reacted in 1908. In this case the division of the stable had been effected by means of a brick wall. Although, during the first few years, a very small percentage of the animals did not pass the half-yearly tests, the result was now and then rather bad, as when, on one occasion, as many as 22 per cent. reacted, which discouraged the owner of the estate so much that he very nearly gave up the whole thing. Fortunately, however, he persevered, and eventually reaped the reward of his exertions.

A well-known cattle breeder—Mr. Ahlmann, of Langholt and Striben (Jutland)—had, in 1895, 271 reacting and 68 healthy animals. At present the reacting division has been reduced to ten, while of the remaining stock on his two farms only six out of 373 animals reacted at the last test. Mr. E. Tutein, of Edelgave (Sealand), had, in 1895, 115 reacting animals and 48 healthy ones; the last time the test was applied, only two out of 158 reacted. As early as 1899 Bang, in the report submitted by him to the Veterinary Congress of Baden-Baden,[1] expressed his opinion that the best way to root out tuberculosis in a large stock among which disease had long been prevalent would be to subject at first only calves and young cattle, and none of the full-grown animals, to the test, as experience has shown that among such a stock 80 per cent. or more of the full-grown animals would react.[2] Consequently only very little would be gained by isolating the 10 or 20 per cent. of non-reacting cows, as a great number of these animals, having for a long time been exposed to infection, would turn out to be infected, even if they did not react. Not a few of such cows will be found to have in some of the lymphatic glands small tubercles of long standing, encysted, it is true, and consequently harmless, but still in some cases liable to break out again. By not subjecting the full-grown animals of their stock to the test, farmers would avoid the unpleasantness of learning (and of having to tell their friends) that the greater part of their stock was infected, and the task of isolation would be the easier at first.

It is really beyond comprehension that every great cattle farmer who is the owner of a valuable herd, and knows it to be infected does not take the simple precaution of isolating his calves from the full-grown animals of his stock and feeding them on uninfected milk, *i.e.* milk that is sufficiently heated or milk from a few perfectly healthy non-reacting and clinically examined cows. In countries where the "artificial" feeding, which is common in Denmark, is unknown, a way out of the difficulty would be to make some perfectly healthy cows act as wet-nurses and suckle the calves. Indeed, as has been proved by the Hungarian Ujhelyi, good results may be achieved even if the mothers are allowed to nourish their own calves, provided the calves are kept in separate stables, except when they are let in to their mother for feeding two or three times a day. This breaking away from the isolation rule involves, of course, some danger of

1. Congress Rept., Vol. 1, p. 541.
2. This view is confirmed by Regnér (quoted by Salmon, B. A. I., Bull. 38, p. 86) and by von Behring (The Suppression of Tuberculosis, trans. by Bolduan, p. 5). Bang had stated that most old animals of a herd in which tuberculosis has existed for many years will react, even though they appear perfectly healthy. To this, as a result of many years' observation, von Behring wishes to add: "*And though they may apparently remain perfectly healthy for their entire life.*" Professor Sir John M'Fadyean (Jour. R. A. S. E., 1910, p. 43) adds another reason in favour of the plan of leaving the older animals untested, *i.e.* ". . . .most owners would prefer not to know for certain that animals which they cannot afford to dispose of immediately are tuberculous. That this is a consideration likely to be taken into account both by owners of milking herds and by those who breed pedigree animals is sufficiently obvious, and the ultimate decision as to whether the adult animals are to be tested or not must be left to the owner himself. It may, however, be maintained that it is as a rule the wisest plan to submit the entire herd to the tuberculin test at the outset, and this plan will find immediate justification when the result of the test is to show that only a minority of the adult animals are diseased."

infection; there is, however, a great difference between such a brief exposure to infection and constant cohabitation in the same stable day and night. Of course, the isolated calves should be subjected to half-yearly tuberculin tests, so that the infected ones may be removed as soon as possible, and the healthy stock which is being formed by the above measures should, of course, be kept continually apart from the old infected stock. The Ostertag method of keeping the healthy animals isolated only as long as they are young, and later stabling them together with the full-grown cattle, cannot by any means be recommended, as the infected stock, even though its sanitary condition may be improved by removing the most infectious animals by means of a careful clinical control, will never be so completely rid of animals that may transmit infection as to obviate further danger. This cannot be attained by the clinical control alone.

For great landed proprietors, owners of several farms, it will be an easy matter to get rid of tuberculosis by sending all the healthy animals of their stock to one of their farms, and gradually—by means of the above method—eliminating the infection from the herds of their other farms. The following account of how matters were managed at the farm of Ourupgaard, and three other farms at Falster, belonging to Mr. Fr. Tesdorpf, may serve as an instance to show how infection may be rooted out in this easy and cheap way. Here a beginning was made in 1893 by subjecting calves and young cattle of the stock of Ourupgaard, but no full-grown animals, to the tuberculin test, with the result that 31 reacted while 152 were found to be healthy. The healthy animals were strictly isolated, first at Ourupgaard in separate stables, later at two of the other farms. During the succeeding years the testing of this healthy stock of young animals, as also calves that were born, was continued. At first the result here, as at many other farms, was sometimes rather unsatisfactory; for instance, in 1896, when 23 animals out of 361 reacted; but in time, as the isolation was carried out more and more carefully, better results were obtained, until last year, when at the four farms belonging to Mr. Tesdorpf, only 11 animals out of 876 reacted. At one of the farms there is still a herd of 114 reacting (or non-tested) animals.

Just as good results have been obtained by Count Danneskjold-Samsoe at his three large farms in the island of Samso. Here, as early as in 1891, a beginning was made by testing the calves, of which relatively few reacted. The reacting animals were killed, and the healthy calves and young cattle were kept isolated for some time, only, however, until the beginning of the calving season—which was certainly a great mistake (one that could not be prevented, the test being a private one). They were then placed in the large, well-appointed stable, together with the non-tested cows, which, though apparently healthy, infected the others, so that when at length Bang, in 1898, prevailed upon Count Danneskjold-Samsoe to have the whole stock, which during six or seven years had been continually recruited with absolutely healthy young animals, subjected to the test, 286 animals reacted, while only 29 were found to be healthy! From that time the healthy animals were kept isolated at two of the other farms. In 1901 there were, at one of these farms, 208 animals, which all passed the test, and at another 126, four of which reacted. In December, 1907, there were in the healthy divisions 593 animals, of which two reacted, though doubtfully, on being subjected to the test. In addition there was still at one of the farms a reacting division of about 30 cows. So the great task of changing a large tuberculous stock into an all but healthy one by breeding had been accomplished in ten years—an excellent result, indeed!

Excellent results may also be obtained by isolation at one farm, as will be seen by the two following instances: In 1896 Farmer Langermann, of Faurholm, had 45 calves subjected to the test, 15 of which reacted. From that time until now the calves bred at the farm have been tested and kept isolated, while the full-grown animals of the stock were not tested at first. That they were highly tuberculous was proved by the fact that 19 of the apparently healthiest cows reacted on their being subjected, in 1900, to the test as an experiment. Gradually a perfectly healthy stock has been bred, numbering—in April, 1908—197 animals, none of which reacted when tested.

At the large estate of Voergaard, in Jutland (belonging to Mr. Scavenius), the same method of leaving the full-grown animals untested at first was adopted. In 1895, ninety-four yearlings and two-year-olds were tested, half of which reacted. The result of continued isolation of the calves and the young cattle and repeated tuberculin tests (of the calves twice yearly, of the older animals only once) is that there were, in 1907, healthy divisions numbering 443 animals, of which only nine reacted upon the application of the test, and a reacting division of 41 animals. The manager of the cattle farm was much struck by the gratifying fact that the cows live much longer now than at the time when tuberculosis was prevalent among them—a fact that is, of course, of the greatest importance as regards the profits of cattle farming, and which is generally taken too little into account. It is by no means only at the large farms that excellent results have been obtained by the method of isolation. It is, indeed, quite possible to carry it out at the small farms as well. The difficulty at these farms is, of course, to find two sets of stable hands to tend and milk the two divisions; but, on the other hand, there is the advantage that at a small farm nothing escapes notice, and that the farmer can personally see to the execution of his orders. A small farmer, if he only has intelligence enough to grasp the main point, can much more easily than a great land-owner, take care that the transmission of infection is avoided. Generally it will not be necessary to have two sets of stable hands, if only the rule of tending and milking the healthy division first is strictly adhered to, and if the hands change their boots or shoes and, preferably, their overalls as well, on going from one division to another, and use different sets of implements in the two divisions.

It is a fact that the carrying out of the method of isolation has been attended with excellent results on many small farms. Where only few animals reacted, it was easy enough to get rid of the disease; but also in cases where almost the whole stock was infected, the gradual elimination was often successfully accomplished. It may here be mentioned that it repays one's trouble to work for small farmers—men who have felt their economic existence threatened by the prevalence of tuberculosis among their cattle. These men are deeply impressed with the importance of getting rid of the disease, and so take more care in performing their daily duties to avoid the transmission of infection than do most others. The result of a computation made by Bang in 1905 was that at 66 small farms, of which the average number of stock was 29 head of cattle, a gradual changing of what were for the most part highly tuberculous herds into healthy ones had been successfully accomplished by the method of isolation. When this work was begun, the total number of reacting animals on these 66 farms was 1,045, and of healthy ones 780; when it was finished, there were 1,896 healthy animals, and none reacting. On being asked, several of these farmers told Mr. Bang that the work had certainly caused a good deal of trouble, but that the expense was nothing to speak of. Thus one farmer had, by spending a sum of less than 200 kr. on the establishment of two provisional byres in one of his farmhouses, succeeded in changing his highly tuberculous stock (12 cows and heifers of which he had had to sell for a mere song within a few years) into a perfectly healthy one, numbering 30 head of cattle—in 1907 there were 36—which have been several times subjected to the tuberculin test, and have each time been found to be healthy. Other farmers have achieved similar excellent results at still smaller cost. It will thus be seen that there is not the slightest doubt that both small and large cattle farmers may gradually change a tuberculous stock into a healthy one, if they are determined to do it, and if they have quite grasped the nature and the modes of infection of tuberculosis.

N. O. Nielsen, veterinary surgeon (Remkolde, near Vordingborg, Sealand), has had the good idea to persuade a great number of the small cattle farmers of his district to join an association, with the object of "promoting the breeding and maintenance of healthy, non-tuberculous stocks of cattle and pigs." Only such farmers are allowed to join as have had their stock subjected to the tuberculin test and, in case of its proving only partially healthy, have suitably isolated the healthy animals from the diseased ones. No increase of the stock by animals of other stock, except calves under one month, is allowed, unless they come from a healthy stock and have been found healthy on being injected with tuberculin. The object of the association is, besides setting a good example, to facilitate the purchase of healthy animals, as members who want to buy or sell may apply for advice to one among them who keeps a list of the farms where healthy animals are for sale. To some of the members is delegated the task of superintending the heating of milk at the dairies. Members pay a subscription of 2 kr. yearly.

The association was started in December, 1905, and has prospered so much that it has now 125 members, possessing stock amounting to 2,740 cows and young cattle. (According to a report, dated January 1st, 1908, 2,070 of the 2,442 animals of the association were healthy, and only 14 of the members had reacting (isolated) animals—372 in all.) Within three years the task of rooting out tuberculosis from 25 stocks of cattle has been accomplished by means of killing or selling the reacting animals. (On the first application of the test 85 stocks—most of them very small, it is true—were found to be healthy.) More than half of the cattle of the four parishes—the scene of the labours of the association—belong to members. There is no doubt that such associations may do much toward rousing an interest in small farmers in the great problem : How to breed healthy cattle and pigs. " Union is strength " may be more truly said of Denmark, where so much is achieved by co-operative farming, than of any other country.

The growing interest in the rational application of the tuberculin test and the method of isolation has, in addition to the founding of the above association, manifested itself lately in another way. During the last seven or eight years several thousand head of Jersey cattle have been imported into Denmark direct from the island of Jersey. These cattle, as well as all other cattle that are imported for breeding purposes, must undergo a brief quarantine detention and are subjected to the tuberculin test (in accordance with the Act of February 5th, 1904, relating to the combating of tuberculosis among cattle and pigs). This has further corroborated the truth of the already well-known fact that tuberculosis is all but unknown among the Jersey cattle—an interesting circumstance which is accounted for by the fact that the Jersey stock has been kept pure for more than one hundred years, the importing of cattle, except for immediate slaughter, being prohibited, probably to prevent the introduction of rinderpest. Of the Jersey cattle imported into Denmark, only very few animals reacted on being subjected to the test, and when these animals were killed it was either quite impossible to demonstrate the presence of tuberculosis (accidental fever), or it was found to be present in a very slight degree only (perhaps caused through human infection ?). On being placed among infected Danish cattle, healthy Jersey cows will very soon become tuberculous ; sometimes even they have been known to give way to the disease quicker than Danish cattle. The man who first imported Jersey cattle, and who is the most eager advocate of the introduction of this excellent breed, which, owing to its wonderfully rich milk, is of special value to a butter-producing country, viz. Mr. J. Larsen (Gaardbogaard), was fortunately also a very eager advocate of the use of tuberculin, and has always taken good care to keep his stock free from tuberculosis. Consequently, it has been easy for him to induce the majority of the cattle farmers who import Jersey cattle to keep their newly imported animals free from the disease by means of isolation. There are at present about 5,000 head of Jersey cattle in Denmark—on small as well as on large farms—most of which are either quite free from tuberculosis or successful efforts are being made to make them so. At many of these farms the stock is composed exclusively of Jersey cattle, at some the breed is mixed.

The foregoing is chiefly an account of what is being done in Denmark to combat tuberculosis among cattle by the cattle farmers, assisted by the State, which pays the expenses attendant on the tuberculin tests on condition that the farmers bind themselves to keep their healthy animals safely isolated from the infected ones. In conclusion follows an account of the two measures with the same object (as passed by the Legislature): The amendment in 1898 of the Tuberculosis Act of 1893 provides that all cows found suffering from tuberculosis of the udder are to be killed, and that a partial compensation is to be paid to the owner by the State; further, that all skimmed milk and buttermilk returned from dairies to be used as food for calves and pigs is previously to be heated to 85° C. In 1904 an amendment was added providing that the compensation for a cow killed on account of tuberculosis of the udder is to be increased a little, so as to represent one-third of the market value of the carcass, calculated at the current average price for meat of inferior quality if the meat is declared by a veterinary surgeon to be fit for human consumption (which happens very rarely), and five-sixths of the market value of the carcass if the meat is condemned. By an amendment of the provision relating to the heating of the milk it was provided that the milk is now to be heated to 80° C. instead of to 85° C., and that this provision is also to apply to cream destined for the making of butter for exportation. The object of this latter provision, which has, of course, in itself nothing to do with the endeavours to combat the prevalence of tuberculosis among domestic animals in Denmark, is to keep Danish butter free from viable tubercle bacilli. It cannot be said to have revolutionised the dairy work to any great extent, as the heating of buttermilk has always been performed indirectly by heating the cream. Long before 1898 it was common enough to heat the cream very considerably in order to ensure the perfect purity of the butter. There is no doubt that the usual heating of the cream and the adding of cultures of acidifying bacteria before the churning have contributed much to the practically invariably superior quality of Danish butter.

The object of the killing of cows suffering from tuberculosis of the udder is to get rid as soon as possible of these animals, through which, more than through any others, infection may be spread to calves, pigs, and other domestic animals, and also, undoubtedly, to human beings, especially children, if the milk is taken raw. The endeavours to combat tuberculosis of the udder have met with great sympathy among Danish farmers. About 2,500 samples of milk of cows, suspected of suffering from this form of tuberculosis, are sent in yearly through veterinary surgeons to the laboratory of Dr. Bang, and the microscopical examination of these samples, either of the particles produced by exudation or—in case of the milk being unchanged—of the sediment after centrifugation, showed tubercle bacilli to be present in about 30 per cent. of the cases. After the killing of the cow parts of the diseased udder are subjected to examination in order to ascertain the correctness of the diagnosis, which in only about 1 per cent. of the cases has turned out to be at fault. About 700 cows are killed every year, and the compensation paid for them generally amounts to 50,000 kr. yearly.

The object of the killing of cows suffering from tuberculosis of the udder is, of course, best attained if the case is established when still at an early stage. The fact is, therefore, worth mentioning that of the 6,228 cows suffering from tuberculosis of the udder destroyed in Denmark in the course of ten years, 2,149, or 34·5 per cent., were still at a very early stage of the disease, as the secretion of the diseased gland still had the appearance of natural or almost natural milk. In many other cases also the rooting out of these infectious animals has had great hygienic importance, as cows suffering from tuberculosis of the udder may often go on living for months after their milk has changed, and even though at this stage the milk is not generally mixed with uninfected milk, it still contributes to spread infection in the stable by being milked on the floor.

The compulsory slaughter of these animals is, therefore, indubitably justified, but much more ought to be done. The best thing would be to order all cows suffering from "open tuberculosis," *i.e.* all which discharge tubercle bacilli through any of the excretory ducts, to be destroyed, and partial compensation granted to the owner. Should the authorities hesitate for the present from acting upon this recommendation—partly because of the expense, partly because it may be rather difficult in some cases to decide whether a coughing cow is suffering from pulmonary tuberculosis, especially of an ulcerative, infectious form—there is, at any rate, one form of tuberculosis which is extremely easy to diagnose, as the presence of the bacilli may be proved directly, viz. tuberculosis of the uterus. This disease, which seems to be even more frequent than tuberculosis of the udder, is most infectious; not only are enormous masses of tubercle bacilli every day spread in the stable through the discharge from the vagina, but a great number are no doubt mixed with the milk during the milking. It is six years since the veterinary authorities of Denmark recommended that the same action should be taken with regard to cows suffering from this disease as with cows suffering from tuberculosis of the udder; but up to the present day their advice has been disregarded.

The most important of all the measures against tuberculosis among cattle and pigs which have been carried out in Denmark is the law relating to the heating of skimmed milk and buttermilk to 80° C. before it is returned from the dairies. As in Denmark nearly all milk not sold directly for consumption is sent to co-operative dairies, it is clear that there is a very great danger of a wide dissemination of tuberculosis if raw skimmed milk and buttermilk are returned to the suppliers to be used as food for calves and pigs. There will always among the suppliers of a dairy be one or more farmers who have a highly tuberculous stock, one or more cows of which yield in the course of the year great quantities of infected milk; and so, by employing this milk, after it has been skimmed, to feed other stocks, the infection is spread to hitherto healthy herds. As mentioned above, this was formerly done on a large scale, and there is no doubt that most stocks of cattle and pigs in Denmark would gradually be infected in this way if measures had not been taken to prevent it. Of course, the heating of the whey ought to have been enforced by law as well; this was proposed, but the proposal was not accepted, chiefly because the heating of the whey is rather troublesome. It is, however, to be hoped that this measure will be carried out some day, though, as whey is mostly used for feeding pigs, it is not so important as the other dairy products, as regards bovine tuberculosis, and, besides, cheese-making is not nearly so considerable in Denmark as butter-making. In Denmark the observance of the law regulating the heating of skimmed milk is controlled by the police as well as by the margarine and butter inspectors, who procure samples at the dairies and send them to the laboratory of Professor Storch, where they are subjected to his colour test, which consists of pouring a few drops of paraphenylene-diamine and peroxide of hydrogen into the milk.

The milk turns blue if it has not been heated to 80° C. (176° Fah.). Offenders against the Act are fined. On the whole, the regulations governing the heating of milk are fairly scrupulously carried out, though, of course, there are exceptions. The best plan would be for one or two of the suppliers of each dairy to apply the above easy and simple test every day. This is done in some places and has produced very good results.

One useful provision of the Tuberculosis Act is that the sediment deposited on the sides of the cream separator is to be burned, which is no doubt always done now. In old days this product was now and then used as food for pigs, and thus many pigs were infected, as it contains enormous masses of tubercle bacilli which are separated from the milk by the centrifugal force.

Principle of segregation

As we have seen, the main principle of the Bang method is segregation of infected individuals, and in this connection it is interesting to note Newsholme's[1] analysis of the causes which have contributed to the decrease of human diseases. He arrives at the conclusion that in the case of tuberculosis, leprosy, and typhus the decrease is due to segregation of the infected patients in institutions.

Bang method

The procedure of Professor Grancher in regard to human patients strikingly reminds one of Bang's method. Dr. Rist[2] referred to it as ". . . . a new scheme of prophylaxis that was brought out by Professor Grancher, of Paris. From the fact that children always are infected by tuberculous parents or other tuberculous members of the family, he came to the conclusion to take the still healthy children to a place where they can be protected from tuberculous infections ; 200 children were taken away from their families and reared in the country or on farms.

" The first condition is a very careful selection of the children, and only an entirely healthy child should be taken from the family. There is a special medical committee appointed for this purpose. The children are sent to country places, thus increasing the number of children who will escape from tuberculous infections. This work was not begun on a large scale ; the cost being very low in France—almost one franc a day a child. In a wealthy country like the United States it should be very easy to follow out this scheme on a greater scale."

SUCCESS OF TUBERCULIN TESTING IN THE ERADICATION OF TUBERCULOSIS.

Maine

Deering[3] considers they are doing rather well in the State of Maine. He says they ". . . . use tuberculin quite freely and adhere strictly to its results. We would hail with joy," he continues, " any other method that would do away with the slaughter of cattle ; yet with our small percentage of tuberculosis in Maine we believe that our policy for us at present, considering our conditions, is working successfully, and that at some future time we shall be able to make a still more favourable report."

Minnesota

In Minnesota " It is stated on good authority," according to Reynolds,[4] " that there is not an untested herd of pure-bred dairy cattle in the State. A considerable proportion of the other breeding herds are reported as tested one or more times."

Dr. Eastwood,[5] after quoting figures, concludes they ". . . . certainly indicate that some progress is being made in Wisconsin towards the eradication of bovine tuberculosis."

1. The Prevention of Tuberculosis, pp. 259, 262, 265.
2. 6th I. C. on T., Vol. 2, p. 512.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 917.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 938.
5. Dr. Eastwood's Rept., p. 4.

[1]" Statistics indicate that much remains to be done before tuberculosis can be eradicated from the very large number of dairy cattle in Pennsylvania. I am told that progress is being made, though perhaps slowly, and that the inspections of animals slaughtered for meat indicate some diminution in the amount of tuberculosis. The work of the Pennsylvania Live Stock Sanitary Board has a high reputation throughout the United States."

Pennsylvania

Mohler and Washburn[2] record two interesting examples of suppression of bovine tuberculosis under the Bang method ". . . . accomplished at the Government Hospital for the Insane, where, in the year 1900, under bureau test, 79 cows gave a decided reaction to tuberculin out of 102 tested ; and also at the National Soldiers' Home, where there were 53 reactions in a herd of 63. These reactors were removed, the stables carefully renovated and disinfected, and all new cows purchased for the completion of the required quota of milk producers were subjected to the tuberculin test before being admitted to the premises. In the succeeding years the usual dairy exigencies required the disposal of several cows annually, but all newcomers were rigidly examined to make sure that they brought with them no tubercular infection into either of these herds, which now number over 300 animals. The tuberculin test was given annual application in both herds, with the result that a few reactions occurred for about three years, since which time no cases have been detected."

Two instances in the United States

Delépine[3] described his Ford Bank experiment in which he cleared a herd of twenty-seven head of cattle in one year, and no fresh case occurred during a second year, although over 61 per cent. of the original stock were tuberculous. " The same method," says Delépine,[4] " has been used since under the supervision of Mr. Brittlebank at a large farm (120 cows) supplying milk to the hospitals under the Manchester Corporation. This farm has now been kept free from tuberculosis for several years."

Ford Bank experiment

Mr. Frank T. Whalle ; herd

It is interesting to note that a committee[5] appointed by the Glasgow Corporation recommended, in 1903, the municipal tuberculin testing of milch cows supplying town milk, and recently the recommendation has been carried into effect in Birmingham with gratifying results. [6]Sixteen herds were taken in hand, and early in 1910 the position was that tuberculosis had been eliminated from eight of these, which were then being kept free. Five herds were in course of being freed. In three instances, on account of the high percentage of infected cows, the farmers, after the first test, declined to proceed farther in the matter. Altogether, of 803 cows tested, 567 were

Glasgow recommendations, 1903

Birmingham work

1. Dr. Eastwood's Rept., p. 12.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 636.
3. Trans. B. C. on T., 1902, No. 2, pp. 235-82.
4. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 241.
5. See The North British Agriculturist, Jan. 11th, 1903, p. 26.
6. See The Brit. Med. Jour., Feb. 26th, 1910, p. 535.

found to be unaffected and 236 were rejected. The cost of this important work had then amounted to £67, and had evidently proved a source of great satisfaction to the Health Committee.

Private enterprise

Mr. John Malcolm, F.R.C.V.S.,[1] Chief Veterinary Officer, Birmingham, reports fifteen herds in and around the city free from tuberculosis at the end of 1910, as shown by tuberculin test.

Dr. H. Renney,[2] Medical Officer of Health, Sunderland, informs us that up to July, 1910, he had issued six certificates to herd owners producing milk under strict hygienic conditions from tuberculin-tested cows. Like the Birmingham scheme, it is voluntary.

Infant milk is sold in Denmark at about double the ordinary price,[3] and the main condition is that it should be from non-reacting cows.

Commercial enterprise in Britain has stimulated a number of companies and private firms to eliminate tuberculosis from their herds, so that milk from tuberculin-tested cows is obtainable in a few districts. A remarkable feature of this movement is that prices have been enhanced only very slightly, yet it seems to yield a financial return.

MAINTAINING THE PURITY OF A CLEARED HERD.

Noack[4] says that to keep tuberculosis out of a cleared herd "....takes as much care and attention as it does to free the herd from this disease."

We have already referred to Marshall's views on re-testing (p. 228).

To maintain the purity of the cleared herds under his control, Bang[5] applies the tuberculin test at least once a year, and has the animals examined by veterinary surgeons twice a month.

Brittlebank works on the same lines, as we are informed by Frank T. Whalley, Esq., whose fine herd is under the special care of this Manchester veterinary officer.

Delépine[6] lays stress upon the importance of *constant supervision*, and contemplates the probability of outbreaks resulting from farmers buying tuberculous cows. Professor Sir John M'Fadyean[7] also insists on constant supervision.

"Farmers are told," says Eastwood,[8] "that when they have got clean herds they must keep them clean. Easier said than done. A single oversight on the part of owners who are keenly alive to the importance of keeping their herds clean may undo the work of years.

1. Rept. of the Medical Officer of Health, Birmingham, 1910
2. Private communication, dated July 19th, 1911.
3. See The Brit. Med. Jour., Mar. 13th, 1909, p. 688.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 993.
5. Private communication.
6. 38th Ann. Rept. L. G. B., p. 410.
7. Jour. R. A. S. E. 1910, p. 45.
8. Dr. Eastwood's Rept., p. 26.

I visited a farmer who started with a clean herd consisting of very valuable pedigree stock. He lent a bull to a neighbour for a few weeks. Some time after the animal's return tuberculosis broke out. The farmer is a wealthy man, and determined to stamp out the disease however much it might cost. After three years he has succeeded, but at the sacrifice of 150 animals, some of them prize winners. For an ordinary farmer, with his living to earn, such a course would have been impossible. In another State I visited a farmer who was making his living out of his dairy and was producing certified milk. His herd was clean; so I was interested to know what precautions he took in buying fresh cows. He considered himself very smart, and explained his methods with much self-satisfaction; but this explanation convinced me that the care he took did not amount to absolute security against introducing the disease. How long his herd will remain clean is more or less a matter of chance. When the disease breaks out in a previously clean herd, owned by a man with a good local reputation for his care and vigilance, much discouragement is caused, and a general impression may be created that the task of keeping out tuberculosis is so difficult as to be practically impossible."

Result of carelessness

New cows

Marshall[1] states that "It has been demonstrated that it is not safe to put newly purchased cows with the old members of a herd till they have first successfully passed a re-test. This can be applied two or three months from the time of the original test, and a double dose of tuberculin should be used."

Salmon[2] says, "A single injection with tuberculin may be sufficient to prevent an animal from reacting until a period of five or six months, or longer, has elapsed after the test was made; on the other hand, some animals react to every injection of tuberculin, even when there are but a few weeks interval."

The International Commission on the Control of Bovine Tuberculosis[3] state that "The prevention of tubercular infection in cattle, free from tuberculosis, consists simply in keeping tuberculous cattle or other animals away from the sound ones; in keeping tuberculous animals out of pastures, sheds, or stables where the sound ones may be kept. Healthy cattle should not be exposed to possible infection at public sales or exhibitions. Raw milk or milk by-products from tuberculous cows should not be fed to calves, pigs, or other animals. Cars that have not been thoroughly disinfected should not be used for the transportation of sound cattle. Cattle that are purchased to go into sound herds should be bought from healthy or sound herds only."

Russell and Hastings[4] inquire: "Is it wise to introduce an unsound or unhealthy cow into your herd? Any farmer about to purchase a

1. 6th I. C. on T., Vol. 4, pt. 2, p. 905.
2. B. A. I., Bull. 38, p. 49.
3. Rept. Int. Com. on C. of B. T., p. 27.
4. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 9.

horse examines it for soundness because he knows an unsound horse will be of doubtful value to him. Yet spavin, ringbone, heaves, cribbing, and balking are not directly transmissible troubles. Tuberculosis, an unsoundness of cattle and hogs, is transmissible to other animals ; hence every tubercular cow is likely to cause the farmer more loss than ten spavined horses, because :—

" (1) Tuberculosis causes the death of a certain number of animals after it has become established in a herd.

" (2) Tuberculosis causes a waste of food when it is fed to animals that cannot give an adequate return.

" (3) Tuberculosis causes heavy loss through the infection of other animals.

" (4) Tuberculosis reduces the productive and market value of cows. As soon as an animal shows physical evidence of the disease it has no market value.

" (5) Tuberculosis destroys the good reputation of a herd, rendering it difficult to sell animals and often hard to dispose of their products. Especially is this true in pure-bred herds."

WHY IS THE BANG METHOD NOT MORE USED ?

Extra work

Pope[1] says, " When first introduced, the Bang method seems to satisfy the farmer ; but it soon loses favour with him. It involves much trouble and expense, and the farmer receives no financial aid from the State. The necessity of Pasteurising the milk from reacting cows may mean heavy loss to the dairy farmer, because under present conditions Pasteurised milk cannot be sold at all or must be disposed of at a lower price than that of raw milk, although its cost of production is greater ; indeed, it is exceedingly doubtful that Pasteurised milk from cows known to be tubercular can ever find a market. Few dairy farmers are in a position to maintain a double equipment ; the per-

Expense

sistent carrying out of the regulations necessary to prevent infection of the well part of the herd, and, in general, the building up of a sound herd by this method, involve trouble and expense which will not pay except in the case of fine milking strains. What has been said of the dairy farmer applies with even greater force to the general farmer, whose system of farm management makes the application of this method impracticable."

" Mr. Henry Wallace, who is intimately acquainted with American farm conditions, writes me," says Pope, " ' I do not think that the Bang method of treatment will be practicable on the average farm, not so much because of the extra labour and expense, but because the farmer ordinarily would rather stand the loss than go to so much trouble.' "

Pearson[2] writes : " The Bang method has not become popular

1. 6th I. C. on T., Vol. 4, pt. 2, p. 575.
2. Quoted by Eastwood, Dr. Eastwood's Rept., p. 9.

in Pennsylvania," and "It is important to note that the Bang system has never been widely used outside of Denmark, and its use is diminishing rather than growing in that country.[1] That is not because it is not effective—it is effective—but because it involves extra labour, watchfulness, care, and expense for such a long time that only a few herd owners have the courage and perseverance to carry it out. It is unfortunate that this is so, for this system furnishes a method to gradually eradicate tuberculosis at a minimum of loss. It is conservative to the last degree. Those who have carried it out correctly have had good results. But we have to take the facts as they are and to recognise that the Bang system in its entirety is not likely to be used extensively in this country (U.S.A.)."

Professor Sir John M'Fadyean[2] reviews the difficulties for the average British farmer in the elimination of tuberculosis from his herd. It is admitted at the outset that the task is not an easy one, and the chief obstacles are the lack of adequate housing accommodation, the inability to make the sacrifice involved in selling valuable breeding or milking animals at butchers' prices,[3] and to see any promise of adequate reward—in obtaining a higher price for the milk from tuberculosis-free cows. The actual loss attributable to the disease, the professor admits, is often not very great, even in herds where a considerable portion of the adult animals are infected. "But the valuable pedigree herds of the country stand on a different footing. In the majority of them sufficient housing accommodation to make possible the separation of the diseased and the healthy already exists, or could be provided without serious expense, and there would be an undoubted gain in the higher prices obtainable for animals sold with a guarantee of freedom from tuberculosis. The purification of these herds could not fail to be profitable to their owners, and it would provide the object lesson most needed to encourage breeders in general to wage systematic war against this widespread disease."

THE BANG METHOD SIMPLIFIED.

"Schroeder has shown," says Dawson,[4] "that it requires only a single nursing of a tuberculous mother cow to infect her offspring. He allowed three sucking calves to nurse a tuberculous cow one, three, and seven days respectively. A fourth calf was fed the milk from a pail for thirty days. All other sources of infection were excluded. All four calves contracted tuberculosis."

1. Bang refers to the "constantly increasing demand" among Danish farmers for tuberculin testing (see p. 252).
2. Jour. R. A. S. E., 1910, p. 45.
3. Hence Delépine's contention that eradication should be carried out before the animals are three years old (see The Veterinarian, July and Aug., 1899).
4. 6th I. C. on T., Vol. 4, pt. 2, p. 737.

Ujhelyi's work

On the other hand, Bang[1] acknowledges that the Hungarian, Ujhelyi,[2] has proved that "....good results may be achieved even if the mothers[3] are allowed to nourish their own calves, provided the calves are kept in separate stables except when they are let in to their mother for feeding two or three times a day. This breaking away from the isolation rule involves, of course," Bang continues, "some danger of infection; there is, however, a great difference between such a brief exposure to infection and constant cohabitation in the same stable day and night."[4]

Ujhelyi describes his practice as follows: "The basis of the Bang method of tuberculosis suppression consists on the one hand in separation of those animals which respond to the tuberculin test from the others, and on the other hand in artificial feeding of the calves with milk warmed to 80° to 85° C. (176 to 185° Fah.). In Denmark the artificial feeding was usual before, and the great number of dairy associations rendered it possible to return the skim milk Pasteurised. The dairy associations in Hungary are, on the whole, smaller, and the purchase of Pasteurising machines cannot be carried out; neither is it usual here to feed calves artificially. I have, therefore, while taking the Bang process as a basis for suppressive measures, adopted Hungarian conditions for its introduction upon several larger and smaller estates—that is, the expensive and complicated process of artificial feeding was abandoned and the calves given to be fostered by cows which did not respond to the test. When new drafts of cows arrived, the foster mothers were selected from these; if none could be found unresponsive to the test, the calves were fed by their own mothers, though these might be responsive;

Conditions in Hungary

1. 6th I. C. on T., Vol. 4, pt. 2, p. 858.
2. Bekämpfung der Tuberculose der Haustiere, Eighth International Veterinary Congress, Budapest, 1905. See Salmon, B. A. I., Bull. 38, p. 83.
3. Tuberculous mothers are referred to.
4. Professor Sir John M'Fadyean (Jour. R.A.S.E., 1910, p. 42) agrees that "....the owner who finds separation of the cows and young calves impracticable need not on that account decide in advance that elimination is impossible for him. It will still be worth his while to maintain the separation between the reacting and the non-reacting cows, and to face the risk involved in allowing the former to rear their own calves. When the calves thus reared come to be weaned, the tuberculin test properly carried out can be trusted to tell him which of them have escaped infection, and these only must be drafted into the sound division of the herd. Should the plan of separating the calves from their mothers be adopted, it will still be obligatory to have the test applied to the calves at weaning time before concluding that they are sound."...."The question whether the reacting and the non-reacting animals should be kept apart when at grass as well as when they are indoors" admits of a similar reply. "The answer to the question must be that when the circumstances permit, it will certainly be best to keep the reacting and non-reacting animals apart in the fields as well as in the houses; but, again, it may be said that if an owner finds this quite impossible he may still with advantage adopt all the other means of elimination that are practicable. The risk that some of the sound animals may contract the disease at grass will be more than appreciable, but very much less than when diseased and healthy are kept under a common roof."

and care was taken meanwhile to allow the calves to be with their mothers only while feeding and to remove them from the cowhouse immediately after weaning. Of these calves fed of necessity, though under proper precautions, by mothers responsive to the test, hardly more, on a yearly average, than 10 per cent. were found to react; while of those fed by non-reacting foster mothers the number reacting, on a yearly average, was 2 to 6 per cent.—results that, even under the application of the original Bang process, could hardly have been bettered. At least, of the 10,533 young animals artificially reared and half-yearly examined upon the Archduke Frederic's estate at Magyar-Ovar, 400—*i.e.* 3·7 per cent.—were found to react to the test; while, on the other hand, during my own researches of 7,296 young animals, only 239, or 3·3 per cent., reacted. It is to be noted that the examinations on three out of eight estates took place every nine months.

"I lately had occasion to introduce and, without much difficulty, to apply the Bang process of suppression, especially in the form adapted to our peculiar conditions, not only to small establishments of some 70 head, but to places with a stock of 150 to 250 and to large establishments of 400 to 700. But the process has also been applied here in its original form at Mezöhegyes; for instance, on a farm of over 1,000 head, which was completely freed from the disease in four or five years; also, on the Magyar-Ovar estate, on a farm of over 5,000 head, where, after five years' treatment, three-fifths of the stock are free from tuberculosis."

Kinnel,[1] of Massachusetts, made practical observations on the herds of Sloane and Colt, and published his results in an article, "Sanitation *versus* Tuberculin in the Eradication of Tuberculosis." He noticed that none of the heifers which had been born and reared by reacting dams responded to the tuberculin. He ascribed this phenomenon to the rule at the Sloane farm, that young animals after weaning were kept separated in the stable from the part which was occupied by the cows. He had the same experience with calves on the Colt farm, where even the sanitary conditions were very bad.

Noack also points out that Ostertag maintains the risk of infection from bovines which react to tuberculin but are not clinically affected is very slight, which contention, however, is in opposition to the findings of Rabinowitsch and Mohler.

Risk of infection from non-clinical cows

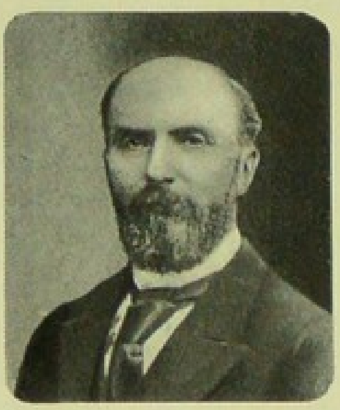
Bang[2] concurs in the view of Ostertag, but realises the danger of a closed infection breaking through at any time, and the difficulty of detecting the advent of the latter condition (see p. 91). Replying in the discussion after reading his paper at the Sixth Congress, Bang said, "....I think there is no danger from the milk if the cow shows no clinical symptoms of the disease." This is notwithstanding the

1. Jour. Comp. Med., 1898, No. 6; cited by Noack, 6th I. C. on T., Vol. 4, pt. 2, p. 992.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 868.

very important feature of his method for suppression of tuberculosis—isolation of calves from infected dams as soon as possible after birth—not more than two days,[1] and the fact that in Denmark "....milk is prohibited from being sold for consumption by children unless it comes from an absolutely clean herd," which latter point Bang brought out in the sentence following the one above quoted to the effect that he apprehended no danger from cows not clinically affected. In this connection, however, we may point to the eloquently expressed and sound views of Deering regarding the gradual, imperceptible transition from health to disease.

Infant milk

J. R. U. Dewar,[2] formerly Professor of the Royal Veterinary College, Edinburgh, in his report to the Ninth International Veterinary Congress at The Hague, goes into this question with convincing force and lucidity, and we submit his information to close our consideration of the matter. "While there may be a little difficulty in separating the diseased animals from the healthy in a breeding herd, there may be considerable difficulty experienced in separating the calves at birth from the reacting dams and having all the milk from the reacting cows boiled or Pasteurised before it is given to the calves. The testing of the cows can be done in a few days, but the boiling of the milk and the feeding of the calves requires from four to six months, and entails a very considerable amount of work. Notwithstanding the conclusions arrived at in the Third Interim Report of the British Royal Commission on Human and Animal Tuberculosis, which emphasises the danger of using the milk of cows affected with tuberculosis, although their udders may be clinically normal, it is possible that the danger from this cause may be exaggerated, and that the risk is less than has generally been apprehended.



J. R. U. DEWAR, F.R.C.V.S.
Sometime Professor of Veterinary Medicine and Principal Royal (Dick) Veterinary Coll., Edinburgh.

"There is no doubt that if the separation of the calves from their dams and the boiling of the milk could be dispensed with, it would simplify the problem of the eradication of tuberculosis in breeding herds to a very great extent. And it is quite possible that, but for the work and trouble likely to be entailed in the separation of the calves and the boiling of the milk, and stated to be absolutely necessary, many a breeder might have availed himself of the test years ago, and been the possessor of a clean herd to-day.

"A few facts from the history of a breeding herd first tested in March, 1895, will show that good results may be obtained without these troublesome precautions.

"The reacting animals were separated from the non-reacting,

1. Private communication.
2. The Scottish Farmer, Nov. 20th, 1909, p. 966.

different attendants provided for each lot, and, as far as contact was concerned, the separation was complete. Then the buildings were thoroughly cleaned and disinfected, the air space and ventilation attended to, and all the animals were turned out a short time every day unless it was very stormy. The cleaning and disinfection of the buildings was attended to periodically, even in the case of those containing the animals presumably healthy. The young calves were allowed to suck their dams, but were never closely fastened up, and during a considerable part of the day the doors were left open so that the calves could run out and in to the byre as they wished. They ran with their dams at grass all summer, and when weaning time came they were completely separated, and never put back into the same building as their dams, but isolated until they could be tested.

"The results of this system were almost entirely satisfactory during the first year. Ten calves were bred and reared from reacting cows, and all of them were healthy; that is, each of the ten calves was tested when from eight to twelve months old, and none of them reacted. Second year nine calves were bred and reared from reacting cows, and all were healthy. Third year eight calves, of which one reacted when tested at about nine months old. It is interesting to observe that the dam of this calf became a persistent buller, and was sent to the butcher. Fourth year seven calves, all healthy. Fifth year eight calves, all healthy. Sixth year five calves, and seventh year three calves. During these seven years four animals which did not react at the first test broke down, reacted, and were transferred from the presumably healthy to the reacting herd. In addition to these, four females amongst animals purchased to add to the herd and quarantined until tested, reacted to the test, and had to be put with the reacting herd. After the seventh year (1901) there were only two reacting cows left. One of these had four calves during the next three years, having twins in 1903; the other had a calf each year, seven in all, the last in 1908, and was sent to the butcher fat at fifteen years old. None of these calves reacted when tested at from eight to twelve months old.

"That is, altogether sixty-one calves, bred from reacting cows, only one of which reacted when tested at from eight to twelve months old, or considerably less than 2 per cent.

"Only two of these calves were not suckled by their own dams. The udder of one cow was observed wrong soon after calving, and her calf was put to another cow, while the cow herself was sent to the butcher. In the other case the bull calf of a reacting cow—an inferior milker—was exchanged for the cow calf of a healthy cow—a much better milker.

"It is interesting to observe the reasons for putting away most of these reacting cows, many of them young. Nine proved barren, three aborted, two had dead calves, two became bullers, and two had bad udders.

"In the face of these facts it seems absurd for veterinarians so invariably to insist on the absolute necessity for boiling the milk of reacting cows before feeding the calves with it. There are few, if any, stockbreeders who would not prefer to send 2 or 3 per cent. of their one-year-olds to the butcher rather than have all the trouble of milking the cows and boiling all the milk before giving it to their calves.

"Many may be slow to accept this, especially in view of the conclusions of the British Royal Commission on Human and Animal Tuberculosis, given in their Third Interim Report published in 1909. That report seems to emphasise the danger of using the milk of reacting cows although clinically healthy and with udders to all appearance normal. But supposing we admit that under these conditions there are occasionally tubercle bacilli present in the milk, they are not always present. The Royal Commission did not find the milk always infective. It is not to be supposed that in the case of the dams of these sixty-one calves tubercle bacilli were present in only one instance. There is little doubt but they had been present at times in other cases, but their numbers probably relatively few; and as 'one swallow does not make summer,' so one bacillus in the alimentary canal of a healthy calf will not cause tuberculosis. It is a different matter altogether injecting tubercle bacilli into the tissues of such susceptible animals as guinea-pigs and rabbits to giving a few of them to healthy calves in their milk.

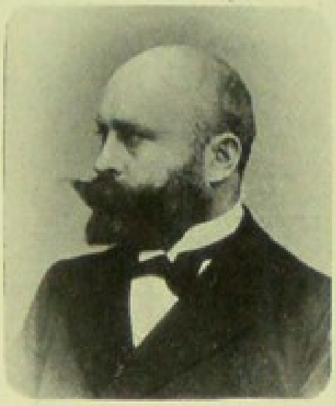
"If we turn to the 'Second Interim Report' of the same Royal Commission, pt. 1, p. 10, we find an account of 'The effects of feeding calves with the bacilli of bovine tuberculosis.' That account deserves very careful consideration, and has hitherto received too little attention. It says: 'In each of six cows whose udders have been made tuberculous by intramammary injection the calves were allowed to suck for varying periods....in one case only was general tuberculosis produced.

"'....The calves which sucked their tuberculous mothers for many days probably ingested no inconsiderable number of bacilli without producing, save in one case only, anything more than a limited and retrogressive tuberculosis.' But the whole account is well worth reading, and shows very clearly that calves are not readily affected with tuberculosis from the milk of their mothers.

"If veterinary surgeons would only recognise this, and would cordially and whole-heartedly recommend the adoption of this system to their clients, there is no doubt but many breeders would be willing to attempt the eradication of tuberculosis from their herds who would never think of it under the conditions requiring the boiling of the milk, etc."

THE OSTERTAG METHOD FOR SUPPRESSION OF BOVINE TUBERCULOSIS.

This method, which is more recent than Bang's system, is thus described by A. M. Trotter, M.R.C.V.S.,[1] Chief Veterinary Inspector for the City of Glasgow: "Ostertag divides all animals affected with tuberculosis into two groups, namely, 'close' and 'open' cases. When the disease is limited to, say, a single nodule in a lymph gland, or to any organ where there is no chance of escape for the tubercle bacilli, then that case falls under the classification of 'close' tuberculosis. On the other hand, if the disease has progressed and there is a large area, the limiting membrane of which has become ruptured, permitting the escape of the contents into any of the passages communicating externally, then it falls under the term of 'open' tuberculosis. An animal affected with 'open' tuberculosis is a source of danger to its fellows by reason of the tubercle bacilli which are expelled from its body. Ostertag aims at the elimination of all these 'open' cases, no matter whether the animal be affected in the udder, in the lungs, in the bowels, or in the uterus. To attain this end Ostertag has formed what he calls farmers' clubs. Each member pays a small annual fee according to the number of animals in his herd, and each year these herds are carefully examined by a veterinary surgeon. If this veterinarian suspects that any animal is affected with 'open' tuberculosis, he carefully collects samples of material, which he forwards to a central institute for bacteriological examination. Further examinations are carried out if circumstances arise which demand them. The greatest care is exercised in the rearing of young stock, and although Ostertag's system has only been in operation for a few years, the most gratifying results have been obtained."



PROF. DR. ROBERT OSTERTAG
Director of the Veterinary Department of the Imperial German Health Office.

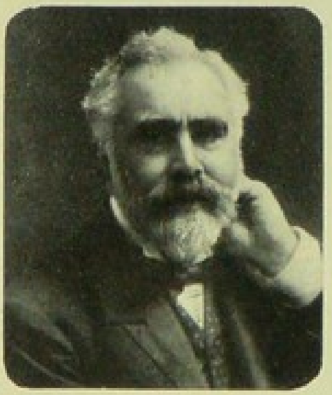
PROFESSOR DELÉPINE'S ISLAND SYSTEM FOR SUPPRESSION OF TUBERCULOSIS.

The earliest reference we can trace to the Island system advocated by Professor Delépine is at a Conference on Tuberculosis held at the Keswick Hotel, and reported in the English Lakes Visitor and Keswick Guardian, April 2nd, 1898. In relation to the control of the bovine disease, Professor Delépine stated:

"We must turn to the actual source of milk—to the cow—and see that it is not allowed to contaminate our milk supply. This meant systematic inspection of cowsheds by competent veterinary

1. See The Scottish Farmer, Jan. 28th, 1911, p. 79.

surgeons; the use of the tuberculin test, in conjunction with careful inspection of each cow; the separation of tuberculous cows from healthy cows; the fattening of cows in a moderate state of tuberculosis for slaughter; the separation of milk from tuberculous cows and its sterilisation before use; the throwing away of all milk from tuberculous udders; the thorough sterilisation of infected sheds before they were used again; the better construction of cowsheds, to make cleaning, lighting, and ventilation more perfect, without going beyond what was absolutely necessary. All these measures would have but temporary effect if no care were taken to prevent the introduction of tuberculous cattle from neighbouring or foreign parts into the county, for he would for the present imagine that they were dealing with the matter as if it were a county question. All cattle brought into the county should be seen and tested by veterinary surgeons appointed by and acting under the direction of some central county authority. All cattle should be marked and registered so as to make it possible to detect at once the introduction of cattle, and also to record the tests to which each animal had been submitted. All cattle should be inspected and tested about twice a year and tuberculous animals weeded out. The breeding of healthy cattle should be encouraged, and provision should be made to keep calves well protected against any chance of infection. Tuberculous persons or animals should be excluded from all dairy farms or dairies. Milk pails, cans, etc., should be kept scrupulously clean, as well as anything coming in contact with the milk. Of the methods he had mentioned, two seemed to be of such a nature that they must be controlled by central authorities—(1) the systematic and periodical inspection of cattle, (2) the testing of all new cattle introduced into a county. It might be said such measures would be useless unless applied to the whole kingdom; but it would be possible to obtain good results by county regulations. A time will come when the danger becomes so apparent that it will be necessary to deal with it. He quite appreciated the difficulties; but delay meant death and increased expenditure."



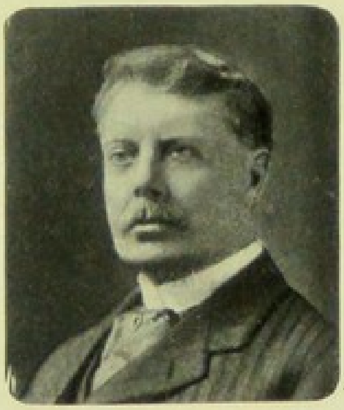
SHERIDAN DELÉPINE,
M.B., C.M., M.SC.
Professor of Public Health and Bacteriology, University of Manchester.
Director of Public Health Laboratory, Manchester.

Since the above system of eradication was recommended by Delépine, he has since defined more clearly the idea of establishing disease-free islands by dividing the whole country into a number of well-defined administrative areas in a certain number of which the regulations would be enforced, and to which, year after year, other districts should be added, until the whole country was under administrative control, a process which Delépine considers would occupy a few years.

It will be seen that Delépine's scheme is practically identical in principle with Bang's, as enunciated a few months subsequently in Paris (see p. 286).

SUMMARY OF THE METHODS OF CONTROL AND ERADICATION OF BOVINE TUBERCULOSIS.

[1]" Owing to the great economic and sanitary significance of animal tuberculosis to the live stock industry of America, and the many and varied factors which must of necessity be taken into account in formulating successful measures for its eradication, the American Veterinary Medical Association, at its meeting in Chicago in September, 1909, appointed the International Commission on the Control of Bovine Tuberculosis. The Commission was instructed to study the problem of tuberculosis among cattle and to report at the next meeting of the Association upon reasonable and economically practicable methods or systems to be recommended to both officials and live stock owners, for eradicating this great scourge of domesticated animals."



Dr. J. G. RUTHERFORD

Veterinary Director General and Live Stock Commissioner, Canada. Chairman of International Commission on the Control of Bovine Tuberculosis.

We cannot better conclude consideration of this important branch of our subject than by an abstract of the report of this Commission.

RESOLUTIONS.[2]

" Based on the information contained in the reports of its committees and on such other information as was brought out in the general discussions of the Commission, the following resolutions were adopted for presentation to the American Veterinary Medical Association.

" 1. DISSEMINATION.

" As a general policy to be observed, all contact between tuberculous and healthy cattle and between healthy cattle and stables, cars, etc., which may contain living tubercle bacilli should be prevented. To accomplish this the following specific recommendations are made :

" (1) There should be no sale or exchange of animals affected with tuberculosis except for immediate slaughter or for breeding purposes under official supervision.

" (2) That the managements of live stock shows should give preference to cattle known to be free from tuberculosis, either by providing special classes for such cattle or in some other practical way, and

1. Report of the International Commission on the Control of Bovine Tuberculosis, p. 7. Government Printing Bureau, Ottawa, 1911.
2. Rept. Int. Com. on C of B. T., p. 8.

should also take every precaution to prevent contact between such animals and those not known to be free from disease.

"(3) All live stock shippers should take every precaution to see that cars furnished are thoroughly cleansed and disinfected before use.

"2. Tuberculin Test.

"(1) That tuberculin, properly used, is an accurate and reliable diagnostic agent for the detection of active tuberculosis.

"(2) That tuberculin may not produce a reaction under the following conditions:

"(*a*) When the disease is in a period of incubation.

"(*b*) When the progress of the disease is arrested.

"(*c*) When the disease is extensively generalised.

"The last condition is relatively rare and may usually be detected by physical examination.

"(3) On account of the period of incubation and the fact that arrested cases may sooner or later become active, all exposed animals should be re-tested at intervals of six months to one year.

"(4) That the tuberculin test should not be applied to any animal having a temperature higher than normal.

"(5) That any animal having given one distinct reaction to tuberculin should thereafter be regarded as tuberculous.

"(6) That the subcutaneous injection of tuberculin is the only method of using tuberculin for the detection of tuberculosis in cattle which can be recommended at the present time.

"(7) That tuberculin has no injurious effect on healthy cattle.

"3. Evidence from Tuberculin Test.

"That a positive reaction to tuberculin in any properly conducted test, official or otherwise, in any animal in any herd, shall be considered evidence sufficient upon which to declare the herd to be infected

"4. Compulsory Notification.

"That this Commission recommends the passage of legislation providing for the compulsory notification by owners and by veterinarians of the existence of tuberculosis in a herd, whether such existence be made known by detection of clinical cases or by the tuberculin test.

"5. Location through Slaughter.

"This Commission recognises that the discovery of tuberculosis in animals slaughtered for food purposes furnishes one of the best possible means of locating the disease on the farm, and therefore recommends the adoption of some system of marking, for purposes of identification, all cattle three years old and over shipped for slaughter.

" As tuberculosis of hogs is almost invariably due to bovine infection, this recommendation should also be made to apply to hogs of any age shipped for slaughter.

" It is further recommended that the discovery of tuberculosis in animals coming under Government inspection should be used whenever identification is possible, as a means of locating infected herds and premises. All such cases should be reported to the proper authorities for control action.

"6. DISPOSITION OF TUBERCULOUS ANIMALS.

" **The Commission Plan.**—(1) As a general policy in the eradication of tuberculosis, the separation of healthy and diseased animals, and the construction of a healthy herd are recommended.

" In order to accomplish this, the following recommendations are made :

" 1. If the herd is found to be extensively infected, as shown by the tuberculin test or clinical examination, even the apparently healthy animals in it should be regarded with suspicion, until they have been separated from the reacting animals for at least three months.

" If, after the expiration of this time, they do not react to the tuberculin test, they may be considered healthy and dealt with accordingly.

" It is recommended that a herd extensively infected should not be treated by the method of general separation, but that the construction of a new herd from the offspring only is advisable.

" 2. If the herd is found, by either or both of the above methods, to contain a relatively small proportion of diseased animals, separation of the diseased animals from the healthy animals, and the construction of a sound herd from the healthy animals, and the offspring of both, is advocated.

" As a working basis in carrying out these principles, we advise :—

" (*a*) That herds containing 50 per cent. or more of diseased animals be treated as coming under section 1.

" (*b*) That herds containing under 15 per cent. of diseased animals be treated as coming under section 2.[1]

" (*c*) That herds falling between these figures be graded according to the option of the owner.

" (*d*) That it shall be the prerogative of the owner to reject either plan and have his herd dealt with by removal and slaughter of diseased animals, with or without compensation, according to the public policy in operation

" (2) That when by any means the officials properly charged with the control of tuberculosis become aware of its existence in a herd to which a policy of slaughter and compensation cannot reasonably be applied, such herd must be dealt with by the owner, under Government

1. Concerning these sections, see page 324.

supervision, on the principle of the separation of all sound animals from those affected. Such separation must be effected by treating the whole herd as diseased, and rearing the calves separately, either on Pasteurised milk or the milk of healthy cows, or when the number of those affected is so small as to warrant such a course, by the application to the whole herd, from time to time, under official supervision, of the tuberculin test, and the entire segregation of all animals found to react.

"In the event of any owner refusing or neglecting to adopt either of the above methods, his entire herd to be closely quarantined, and sales therefrom to be entirely prohibited.

"(3) That a policy of compensation be recommended as useful and usually necessary as a temporary measure.

"(4) That, when slaughter is necessary, in order to avoid economic loss, every effort should be made to utilise as far as possible the meat of such animals as may be found fit for food on being slaughtered under competent inspection.

"(5) The details of the Commission Plan will be found fully set forth in the Appendix to this report (see p. 323).

"7. PREVENTION.

"(1) That with the object of preventing the spread of infection, persons buying cattle for breeding purposes or milk production should, except when such purchases are made from disease free herds, which have been tested by a properly qualified person, purchase only subject to the tuberculin test. In order to assist in the proper carrying out of this suggestion, the Commission recommends that official authorities should adopt such regulations as will prevent the entry to their respective territories of cattle for breeding purposes or milk production unless accompanied by satisfactory tuberculin test charts.

"(2) That all milk and milk by-products used as food should be properly Pasteurised unless derived from cows known to be free from tuberculosis.

"8. CONTROL OF TUBERCULIN TEST.

"That the Commission recommends the passage of legislation which will prevent the sale, distribution or use of tuberculin by any persons other than those acting with the full knowledge or under the direction of official authorities.

"9. EDUCATION.

"As a clear knowledge of the cause and character of tuberculosis among animals, the modes of dissemination and its significance as an economic and as a public health problem, underlie an intelligent adherence to the principles that must be observed in all efforts for eradication, as well as the establishment of proper co-operation in the great work between physicians, veterinarians, live-stock owners, legislators, and the public generally, it is recommended that a wide-spread campaign of education be undertaken. To accomplish this end it is recommended that, first of all, a simple pamphlet on bovine tuberculosis be written, in which the language used shall be of such character that every person of average intelligence shall be able to read it without being mystified by technical terms or phrases. This pamphlet should be published with the endorsement of the American Veterinary Association and the special endorsement and consequent authority of the International Commission on Bovine Tuberculosis Control.

"10. PUBLICITY.

"In concluding its work the Commission desires to especially appeal to the press, metropolitan, agricultural, and local, to join in the work of extending as much as possible among the people the conclusions here arrived at. The vital importance of the life of farm animals to the welfare of all classes of society needs no argument in its support. The aim and sole purpose which has actuated this Commission has been to arrive at the soundest conclusions possible in the light of the best knowledge obtainable.

"11. LEGISLATION.

"It is recommended that legislation regarding the control and eradication of tuberculosis among domestic animals be made uniform; that the laws of the United States and Canada and other American countries for the admission into America of animals from without be made stringent and as much alike as possible; and that the laws governing the interstate and interprovincial movement of cattle and that between different American countries be harmonised.

"The laws governing interstate and interprovincial movement of cattle should be of such character that every State and every province will be free in its eradication work from unnecessary difficulties due to the existence of the disease in other States and provinces.

"Legislation is especially required to prevent the various frauds which interfere with the satisfactory use of tuberculin as a diagnostic agent for tuberculosis, as well as for official supervision over all tuberculin sold to be used by veterinarians and others.

"12. SANITATION.

"In the eradication of tuberculosis it should be kept in mind that, in addition to protecting the animals against exposure to tubercle bacilli, it is desirable to make them as resistant to infection as possible. This can be done by stabling them in clean, disinfected, and properly lighted and ventilated barns, giving them abundant clean water and nutritious food, a sufficient amount of daily exercise in the open air, and attending generally to those conditions which are well known to contribute to the health of animals.

"The daily removal of manure from stables, and water-tight floors and good drainage in stables are urgently recommended.

"Young stock particularly should be raised as hardy as possible, and should be accustomed to liberal exercise and living in the open.

"13. Immunisation.

"That as none of the various methods for the immunisation of animals against tuberculosis have passed sufficiently beyond the experimental stage, the Commission is unable to endorse any of these for practical use at the present time.

"14. Animal Tuberculosis and Public Health.

"While the members recognise that the subject with which this Commission is primarily intended to deal is the control and eradication of tuberculosis among animals as an economic problem, they cannot feel satisfied without declaring their recognition of the fact that tuberculosis among animals is also an important public health problem. Considered as such, the eradication of tuberculosis among animals should have the approval and support of all those persons who are interested in curtailing human suffering and prolonging human life.

"15. General Statement.

"The members of the Commission wish it to be clearly understood that they recognise the limitations of a report necessarily based on actual and not on theoretical conditions. They fully realise that in the event of the policy of which their recommendations form the framework being anywhere adopted even in its entirety, much greater benefit will be derived, at least for some time, from its educative than from its executive features.

"The control, to say nothing of the eradication, of bovine tuberculosis is impossible of achievement without the hearty co-operation of the men who are actually engaged in the cattle industry. In order to secure this co-operation, it will doubtless be necessary, in most communities, to carry on an active and prolonged educational campaign.

"It is apparent that in the dissemination of practical and reliable information regarding the disease, it will be possible to employ a very large variety of methods. Many of these methods, such as bulletins, lectures, and actual demonstrations of disease, having already been found valuable, will doubtless continue to be largely used.

"It must not be forgotten, however, that in this, as in any other educative process, a measure of disciplinary control is essential to success. Needless to say, such control can be secured only by the passage of legislation which, while clear and comprehensive, must, at the same time, be sufficiently conservative to avoid exciting alarm or arousing antagonism on the part of owners, especially of valuable herds.

"The best law ever framed can be made an utter failure by stupid or injudicious administration, while, on the other hand, the most drastic legislation can be rendered acceptable if enforced with reasonable tact and diplomacy. Provided, therefore, that these qualities, combined with integrity, thoroughness, and determination, are available for administrative purposes, the members of the Commission are convinced that the enforcement of a law based on their recommendations will prove to be far the most powerful and effective educational agency which could possibly be employed.

"In concluding its report, the Commission would suggest that the Association should make such provision as may be necessary to carry on the work either by continuing the Commission as at present constituted or with such changes in the personnel as may be considered desirable.

"(Signed) WM. C. EDWARDS. J. W. FLAVELLE.
J. N. HURTY. V. A. MOORE.
E. C. SCHROEDER. F. TORRANCE.
J. J. FERGUSON. W. D. HOARD.
J. R. MOHLER. MAZYCK P. RAVENEL.
T. W. TOMLINSON. CHAS. A. HODGETTS.
J. G. RUTHERFORD, *Chairman.*
M. H. REYNOLDS, *Secretary.*"

[1]"The control of bovine tuberculosis involves a definite procedure under two distinct and different conditions, namely: (1) Where a herd of cattle is free from tuberculosis and is to be kept so, and (2) where one or more animals in the herd are infected and the purpose is to eradicate the disease and establish a sound herd."

(Procedure under Condition 1 has already been given on p. 307.)

"The eradication of tuberculosis from infected herds requires for conservation of the herd different procedures according to the extent of the infection. For a guide to the control of the disease tuberculous herds may be divided into three groups, namely:—

"(1) Where 50 per cent. or more of the animals are infected.

"(2) Where a small percentage (15 per cent. or less) of the animals are affected.

"(3) Where a large number (15 per cent. to 50 per cent.) of the animals are diseased.

1. Rept. Int. Com. on C. of B. T., p. 27.

" In eliminating tuberculosis from infected herds the following procedure is recommended :—

"GROUP I.

" Herds where a tuberculin test shows 50 per cent. or more of the animals to be infected should be treated as entirely tuberculous. The procedure here is as follows :—

" (1) Eliminate by slaughter all animals giving evidence of the disease on physical examination.

" (2) Build up an entirely new herd from the offspring. The calves should be separated from their dams immediately after birth and raised on Pasteurised milk or on that of healthy nurse cows. This new herd must be kept separate from any reacting animals.

" (3) The young animals should be tested with tuberculin at about six months old, and when reactors are found at the first or any subsequent test—the others should be re-tested not more than six months later. When there are no more reactors at the six months' test, annual tests should thereafter be made. All reacting animals should at once be separated from the new herd, and the stables which they have occupied thoroughly disinfected.

" (4) When the newly developed sound herd has become of sufficient size, the tuberculous herd can be eliminated by slaughter, under inspection, for beef.

"GROUP II.

" (1) The reacting animals should be separated from the non-reacting ones and kept constantly apart from them at pasture, in yard, and in stable.

" (*a*) *Pasture.*—The reactors should be kept in a separate pasture. This pasture should be some distance from the other or so fenced that it will be impossible for the infected and non-infected animals to get their heads together.

" (*b*) *Water.*—When possible to provide otherwise, reacting cattle should not be watered at running streams which afterwards flow directly through fields occupied by sound cattle. The water from a drinking trough used by infected animals should not be allowed to flow into stables, fields, or yards occupied by sound animals.

" (*c*) *Stable.*—Reacting cattle should be kept in barns or stable entirely separate from the ones occupied by the sound animals.

" (2) Calves of the reacting cows should be removed from their dams immediately after birth. Milk fed these calves must be from healthy cows, otherwise it must be properly Pasteurised. These calves should not come in contact in any way with the reacting animals.

" (3) The non-reacting animals should be tested with tuberculin in six months, and when reactors are found at the first six months, or any subsequent test, the others should be re-tested not more than six months later. When there are no more reactors at the six months' test, annual tests should thereafter be made. All reacting animals should at once be separated from the new herd, and the stables which they have occupied thoroughly disinfected

"(4) The milk of the reacting animals may be Pasteurised and used.

"(5) Any reacting animal which develops clinical symptoms of tuberculosis should be promptly slaughtered.

"(6) An animal that has once reacted to tuberculin should under no circumstances be placed in the sound herd.

"(7) As soon as the sound herd has become well established, infected animals should be slaughtered, under proper inspection.

"GROUP III.

"Herds that come within this group should be dealt with either as in Group II., where the herd is separated, or as in Group I., where all of the animals are considered as suspicious and an entirely new herd developed from the offspring."

DISINFECTION.

Pope[1] says that "Disinfection is a science, and the average farmer is quite incapable of carrying it out himself; time, skill, and proper appliances are lacking; and, therefore, disinfection by the farmer is usually a mere farce. It is unnecessary to add that unless this work is thoroughly done, it is quite useless to clean up the herd."

Notwithstanding this hopeless view, the farmer may learn. We can at least provide him with reliable practical information, and hereunder add an abstract[2] of the California Agricultural Experiment Station, Circular 19.

"The great importance of thorough disinfection of stables to prevent spread of disease, especially in case of such deadly diseases as tuberculosis, glanders, and many others, and the general lack of exact knowledge as to how such disinfection can be accomplished, has led C. M. Haring, of the California Experiment Station, to compile the following simple directions for securing disinfection and sanitary conditions in stables.

"**Permit the Entrance of a Plentiful Amount of Light.**—The bacteria of tuberculosis and most other disease-producing germs are destroyed by the direct rays of the sun within a short time. They are destroyed by less intense light more slowly, and will live for long periods in dark places. There are numerous other advantages in having plenty of light in a stable that are not necessary to mention here.

"**Clean the Stable Thoroughly.**—Cleanliness is an important adjunct

1. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
2. Compiled at the Office of Experiment Stations and published in Farmers' Bull. No. 273, U.S. Dept. of Agri., p. 14.

to the work of disinfection. The cleaning of the stable includes: (*a*) Removal of manure; (*b*) removal of piles of fodder; (*c*) removal of rotten woodwork and loose boards, especially the floor; (*d*) sprinkling with a disinfectant to lay the dust, and sweeping of the ceilings, walls, and floor; (*e*) removal of dried accumulations about mangers, floors, and drains. The practice of washing the floors and ceilings with water before applying the disinfectant has, in most instances, the disadvantage that the water carries the micro-organisms to be destroyed into cracks, where they will not be affected by the later application of the disinfecting solution.[1]

"**Apply Chemical Disinfectants.**—After the stable has been treated as recommended above, it is ready for the application of chemical disinfectants. These are substances which poison the germs. There are many of them. Some are far more efficient than others. Among the most active are carbolic acid and corrosive sublimate.

"Carbolic acid, when pure,[2] is crystalline. It readily assumes the liquid state in the presence of a little water. As usually dispensed it consists of 95 parts of pure acid and five parts of water. For use as a stable disinfectant, this should be mixed with water in the proportion of one to twenty, or one pint of acid to two and a half gallons of water. The 'crude carbolic acid, saturated solution' is much weaker than the above and should not be diluted with water."

Bichloride of mercury, or corrosive sublimate, is a most active germicide, and has the advantage over carbolic acid for use in a dairy stable in being odourless. This substance is poisonous and must be used with great care. Before it is applied it must be dissolved in water, in the proportion of one part to one thousand One ounce of corrosive sublimate dissolved in eight gallons of water makes a solution of the right strength. In making the solution the corrosive sublimate should be dissolved in one gallon of hot water and then mixed with enough cold water to make eight gallons. It corrodes metal, hence the solution should be kept in a wooden tub or earthenware crock.

1. Russell and Hastings say: "The stable should receive a thorough cleaning. Remove all litter and loose woodwork, such as box mangers; scrape walls and floors to remove *all* accumulations of dried manure and dust. This can best be done after moistening with a 1 to 1,000 solution of corrosive sublimate (one-half ounce to 4 gallons of water). Keep the solution in wooden vessels and remember that it is a strong poison for animals. This solution serves to prevent dust during the cleaning. The removal of litter and dust removes most of the tubercle bacilli from the stable and allows the disinfectant to come in contact with the remainder. Tubercle bacilli in dried manure cannot be killed easily by any disinfectant. Do not place the material removed in the barn yard where cows have access to it, but burn or otherwise dispose of it" (Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 22).

2. It is quite unnecessary to use the pure expensive article for disinfection. A solution of sulphate of copper (bluestone), 6 ozs. to the gallon, is also recommended. A highly effective solution may be made up as follows: Corrosive sublimate 2½ drams, hydrochloric acid (spirits of salts) 2½ ozs., 2 gallons water; wash off after disinfection.

There are many other efficient disinfectants, but the two above described are cheap and obtainable at any drug store. In the employment of commercial disinfectants it is necessary also to know the destructive value of the solutions for the organisms to be destroyed. There are many so-called disinfectants that, in the strength of the solutions recommended, are inefficient.

Disinfectants cannot destroy germs with which they do not come in contact. The disinfectant should be applied in sufficient quantity to thoroughly saturate the surfaces, including the adhering particles of dirt. In the application of the disinfectant it is well to use a broom and thoroughly scrub the floor and lower parts of the walls. The solution can be applied to the ceilings and upper parts of the side walls with a spray pump, and must be carried into every crevice and recess into which dirt can enter.

After disinfecting, whitewash[1] the stable. Although whitewash is not an active disinfectant in the usual meaning of the term, it is an excellent purifier, and should in all cases be used in stables after they have been thoroughly cleansed and disinfected with other agents. If chloride of lime is added to whitewash in the proportion of one pound to three gallons, the value of this application is greatly increased. It is advisable to whitewash cow stables frequently, at least once in six months, and better, every three months. Hot whitewash for this purpose is better than cold.

[2]"In discussing the importance of disinfection of stables and the danger of neglecting it, Dr. Haring points out that 'negligence in properly disinfecting stalls and stables where animals affected with contagious diseases have been is frequently the cause of a reappearance of the disease.' The germs of glanders, for example, may remain alive in stables for several months after the diseased animals have been removed, and if thorough disinfection is not resorted to, all animals housed in the stable are subject to infection from this source."

"'Many failures to eradicate tuberculosis from dairy herds by the repeated application of the tuberculin test and the prompt removal of all reacting animals are due to the fact that the stables were not disinfected.' Tuberculosis spreads rapidly among cattle closely herded together. To prevent this, stables should be thoroughly disinfected at least once a year."

1. Russell and Hastings give the following instructions for whitewashing: "Prepare whitewash as follows: To each 100 parts of *fresh* lime add 60 parts of water; the result should be a dry powder. Sift the slaked lime and add water at the rate of four quarts of water to one of lime if the wash is to be applied with a brush. It is preferable to apply it with a spray pump, since by this method it can be forced into every crack. For this purpose the solution must be thinner than where applied with a brush. Whitewash the barn at intervals of six months, or at least once a year." (Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 23.)
2. See Farmers' Bulletin, No. 273, U.S. Dept. of Agri., p. 15.

According to von Behring,[1] "....the German Regulations of June 23rd, 1880, and May 1st, 1894, refer to the following disinfecting agents :—

"(1) Water, steam, hot water, boiling for one hour.

"(2) Soap suds.

"(3) Soda-lye solution (at least 2 kilos soda in 100 litres water = a little over three ounces per gallon).

"(4) Freshly slaked lime, powder, and milk of lime, 1 to 2 of water and 1 to 20 of water.

"(5) Solution of chloride of lime, 1 to 3 of water and 1 to 20 of water.

"(6) Solution of carbolic acid, 5 per cent.

"(7) Solution of crude cresol 5 per cent. (Liquor Cresoli saponatus of the German Pharmacopœia[2]).

"(8) Coal-tar and wood-tar.

"(9) Fire

FIG. 8.
Hand Sprayer for Disinfectants.

"The most reliable and cheapest agent for rendering harmless tuberculosis virus in stables is hot 2 per cent. soda solution whenever a surface disinfectant is desired. Disinfection of the stable air is as yet to be classed only as a pious wish."

Von Behring did not find formaldehyde gas efficient for stable disinfection.

Concerning disinfection, the International Commission on the Control of Bovine Tuberculosis[3] recommend that "....all litter should be removed; floors, walls, and ceilings carefully swept; and the floors, together with mangers and gutters, thoroughly scrubbed with soap and water. Thorough cleansing before the application of the disinfectant cannot be too strongly emphasised. After cleansing, the disinfectant should be applied. A 5 per cent. (5 p.c.) solution of carbolic acid, a 1–1,000 solution of corrosive sublimate, or a 4 per cent. (4 p.c.) solution of sulphuric acid may be used.

"When the stable can be tightly closed, formaldehyde gas properly used is reliable and satisfactory.

"If tuberculous cattle have been kept in a small yard, the litter should be removed, the surface ploughed, and the fencing and other fixtures thoroughly cleansed and disinfected."

The regulations of the State of Minnesota demand mercuric chloride (corrosive sublimate) or carbolic acid for disinfection. Salmon[4] recommends, however, that "Poisonous disinfectants or those having a strong or lasting odour should, if possible, be avoided. A thin limewash

1. The Suppression of Tuberculosis, p. 61.
2. This is identical with the liquor cresoli compositas of the British Pharmacopœia, while the liquor of the same name in the United States Pharmacopœia is also identical except that it contains no alcohol.
3. Rept. Int. Com. on C. of B. T., p. 28.
4. B. A. I., Bull. 38, p. 90.

made from freshly burned lime is the most satisfactory disinfectant to use about a stable. Its activity may be increased by the addition of four ounces of formalin to one gallon of lime-wash. Corrosive sublimate and carbolic acid are often recommended for this purpose, but as both are dangerous poisons, and as the latter has an objectionable and persistent odour, it is deemed best to use lime-wash and formalin, which probably are just as effective in destroying the tubercle bacillus."

After disinfection of a stable, Professor Sir John M'Fadyean[1] considers the animals should not be admitted until twenty-four hours have elapsed.

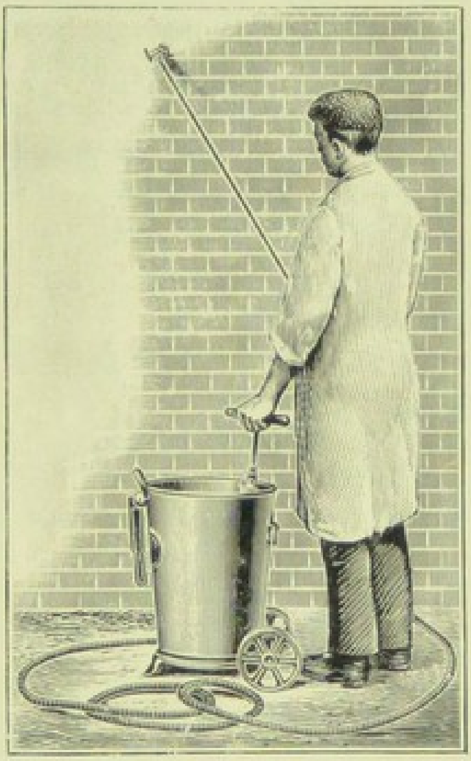


FIG. 9.—Spraying Machine.

Concerning the selection of the disinfectant used, it would appear that the high esteem in which mercuric chloride, carbolic acid, and hypochlorites are held has been based upon tests made with so-called "naked" bacteria, that is, bacteria in pure culture and unprotected with other organic matter. Within recent years, however, investigators have realised that germs do not occur in nature in this condition of cleanliness. Tubercle bacilli, for example, occur in sputum, pus, fæces, etc., and the efficiency of a germicide must depend upon its power of penetrating such media to reach the bacilli. Many animal excretions are of an albuminous nature, and mercuric chloride combines readily with albumen, becoming thereby inoperative as a germicide. Permanganate of potash and hypochlorites attack organic matter with great avidity, thereby becoming converted into other substances quite harmless to bacteria. The readiness with which a disinfecting solution mixes with the matter it is applied to is also of importance. The surroundings of animals contain appreciable traces of fatty matter which are not readily penetrated by watery solutions of any of the above-mentioned chemicals. Their poisonous nature for higher animals, destructive character for ordinary utensils, clothing, etc., must also restrict their use.

Chemists and biologists have, therefore, sought an ideal germicide which would penetrate the habitat of germs, while retaining its power to kill the germs quickly: a substance harmless to animals and not destructive to utensils and clothing.

1. Jour. R. A. S. E., 1910, p. 39.

Most of the investigations on the efficiency of disinfectants have been directed to their application in human practice, but the principles thus elucidated apply in great measure to the objects we have under consideration.

Thus, Major C. E. P. Fowler,[1] of the Royal Army Medical Corps, compared the action of a number of disinfectants on "naked" and "natural" bacteria by mixing the germicide with, in the one case, a beef-tea culture of typhoid bacilli, or *Bacillus prodigiosus*, and in the case of the "natural" bacteria a mixture of human fæces and urine.

The power of carbolic acid (phenol) was taken as a standard, and the method employed that of Rideal and Walker,[2] whose names stand pre-eminent in the investigation of the standardisation of disinfectants. The disinfecting power of pure carbolic acid was taken as 1, and the relative power of the other disinfectants expressed by a figure termed the "phenol co-efficient."

Fowler found that the disinfectants of the tar derivative series (phenol, cresol, etc.) acted in practically the same manner against both "naked" and "natural" bacteria, but a very marked difference was seen in the case of mercuric chloride, permanganate of potash, and iodine. The co-efficients for those named are shown in the table below.

	Against "naked" bacteria.	Against "natural" bacteria.
Phenol	1	1
Mercuric chloride ..	3,000	2·5
Permanganate of potash	40	7
Tincture of iodine ..	18	0·5

Hypochlorites such as chloride of lime, we may mention, behave in a similar manner. Fowler insists upon the necessity of intimate contact between the disinfectant and the matter to be disinfected. Dousing or flooding of a mass such as fæces, he points out, is useless.

Three years later Dr. W. G. Savage[3] published results of his testing of kerol and cyllin, both of which are products of coal-tar derivatives. The results showed that both these disinfectants were capable of killing out tubercle bacilli in dried sputum in a 1 per cent. solution, acting for three hours. When dilutions of 1–200 of these disinfectants were employed they failed to kill all the tubercle bacilli, and tuberculosis resulted in the inoculated animals.

Shortly afterwards Savage[4] published a further note upon the germicidal action of kerol. Reverting to his previous results, he remarks that "The 1–200 dilution of kerol, however, evidently exerted some germicidal effect, since the resulting tuberculosis was slight,

1. Jour. of the Royal Army Medical Corps, Jan., 1906.
2. Jour. of the Sanitary Institute, Vol. 24, pt. 3, 1903.
3. Public Health, May, 1906.
4. Public Health, Aug., 1906.

and the animal showed an increase in weight. A fresh series of experiments was therefore carried out to obtain more exactly the germicidal capability of kerol upon the tubercle bacillus."

Fresh sputum from an advanced case of consumption, and showing abundance of tubercle bacilli on microscopic examination, was spread thickly on wooden slips and carefully dried. These slips were then immersed in solutions of the disinfectant for three hours at the ordinary temperature—dilutions of 1–130, 1–150, 1–170, 1–180.

Five healthy guinea-pigs were inoculated subcutaneously, kept under healthy conditions, some thirty-one, some thirty-two, days after the inoculation. The result showed that while one animal (control animal) inoculated with the untreated sputum developed tuberculosis in a very marked degree, none of the others were affected.

Savage concludes that 1–180 kerol is a satisfactory germicide for tubercle bacilli in three hours and at room temperature, even when completely dried and protected by a thick coat of dried mucus.

Dr. Sommerville[1] found the co-efficient of 22 for kerol on the diphtheria bacillus, that is, kerol is 22 times more powerful than carbolic acid.

In considering the relative poisonous effects of various disinfectants, carbolic acid has again been accepted as the standard. The toxicity of modern germicides is less than that of carbolic acid, and the germicidal power is higher. Professor Hewlett[2] therefore suggested that the toxicity of carbolic acid should be expressed by the figure of 100 instead of unity, as in the case of germicidal power.

The preparations known by the names of cyllin, lysol, Liquor Cresyl saponatus of the German Pharmacopœia, and kerol are all coal-tar derivatives containing soap, therefore readily saponify or emulsify fatty substances, are not caustic, and comparatively non-poisonous. Hewlett quotes the results of Dr. Sommerville,[3] who found that considerable quantities of cyllin could be given *per os* and intravenously to guinea-pigs, rabbits, cats, and dogs without harm. Thus guinea-pigs, rabbits, and cats received *per os* 3–5 c.c. doses (repeated) of 5 and 10 per cent. solutions.

C. J. Martin[4] states that the toxic dose of carbolic acid by the mouth for man is 10 grammes according to Kobert, and 10 to 20 grammes according to Löw. Hewlett[5] determines the toxicity of disinfectants by intraperitoneal injection into guinea-pigs. Using 10 per cent. solutions, he compared kerol and lysol, finding that the fatal dose of kerol is about 8·5 c.c. per kilo of body weight, while the fatal dose for lysol is 8 c.c. per kilo of body weight. The fatal dose of carbolic acid was found to be 10 c.c. of $2\frac{1}{2}$ per cent. solution, which is only a quarter of the strength of the solutions of kerol and

1. The Local Government Officer and Contractor, Feb. 2nd, 1907, p. 781.
2. The Medical Times, June 27th, 1908.
3. Jour. of Tropical Medicine, July 1st, 1905.
4. The Brit. Med. Jour., 1904, II, p. 901.
5. The Medical Times, June 27th, 1908.

lysol stated above. A 10 per cent. solution of carbolic acid would be markedly caustic.

Converting the 10 per cent. solutions to the uniform basis of $2\frac{1}{2}$ per cent. solutions, to compare with carbolic acid of the strength used, we arrive at 34, 32, and 10 as the relative quantities of kerol, lysol, and carbolic acid respectively. Taking carbolic acid as 100 we thus arrive at the figures 31 and 29·5 as the toxicity co-efficients for lysol and kerol respectively.

Hewlett terms this co-efficient the "absolute toxicity co-efficient," because it refers simply to the toxic power of the substances in question. He points out, however, that a more useful co-efficient would be arrived at by taking into account the germicidal power of the disinfectants. Thus lysol gives by the Rideal-Walker method on the typhoid bacillus a carbolic co-efficient of about 2·5 and kerol about 19. The *relative* toxicity co-efficient of lysol will therefore be 12·5, and of kerol 1·6, carbolic acid being taken at 100.

Hewlett obtained similar results by administering the disinfectants by the mouth, and concludes that "These results suggest that both lysol and kerol are comparatively innocuous; for a man weighing 70 kilogrammes, if equally susceptible, the corresponding doses would be 500–1,000 c.c.[1]; that is, 500 c.c. would probably be innocuous, 1,000 c.c. might be poisonous. Taking Martin's figures for the toxic dose, 100–200 c.c. of a 10 per cent. solution of carbolic acid would be the fatal dose for a man of this weight. If anything, kerol seems a trifle less toxic than lysol. Neither, in strength of 10 per cent., seems to produce any local irritant or caustic effect on the mucous membrane of the mouth or stomach. These are important advantages over carbolic acid, the caustic action of strong solutions of which adds materially to the risks arising from poisonous doses."

It thus becomes clear that kerol is the most powerful germicide and the least poisonous of the disinfectants considered. As already stated, it is of the nature of a soap, is not caustic, and readily mixes with whitewash.

MODES OF INFECTION OF BOVINES.

Scepticism regarding the bacillus

Brittlebank[2] informs us that a veterinarian of his acquaintance does not believe tuberculosis in cattle is caused by a bacillus. The same view seems to be timidly admitted in some American literature of a decade ago. Bang[3] tells us there are a few such visionaries.

We may pass over this scepticism, however. Mistakes have been made in science, but none so great as would be involved if such scepticism were well grounded. Professor Woodhead[4] explains that "The interval between the infection and the manifestation of the disease is so great that many observers could not bring themselves to believe that cause, as we now know it, and effect were in any way

1. Roughly, between a pint and a quart.
2. Private communication.
3. 6th I. C. on T., Special Vol., p. 208.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 664.

associated." Bang still further accounts for the scepticism (see p. 293).

How the organism enters and obtains lodgment in the animal body, however, Mohler and Washburn[1] tell us, is not absolutely known. "There are two principal ideas on this subject, both of which have many adherents among leading scientists. One opinion, which has been adhered to for years, is that the principal mode of infection in tuberculosis is by the inhalation of bacilli-laden air, thus permitting the almost direct lodgment of tubercle bacilli within the lungs, with subsequent development of pulmonary lesions, which are generally the most pronounced alterations present. The opposite view, while admitting that pulmonary tuberculosis is by far the most common form of the disease, holds that the lungs become diseased indirectly as a result of the tubercle bacilli entering the system by the mouth, after which they are swallowed (ingestion), taken up by the intestinal lacteals without any injury to the intestinal mucous membrane, pass into the thoracic duct, thence into the venous circulation, and, finally, are filtered out of the blood by the lungs.[2] That this latter opinion is correct in a great number of instances is supported by numerous careful experiments of the Bureau,[3] and is probably the chief method of infection, especially in animal tuberculosis. That other modes of entrance for the tubercle bacilli are present in addition to their entry through the digestive and respiratory tracts is evident by a study of such localised lesions as tuberculous genitals of a bull, or a local tuberculous arthritis of the hock joint, indicating, respectively, infection by way of the genital tract and by direct inoculation through the skin."

Inhalation or ingestion?

"The channel by which the infection occurred may generally be determined," says Salmon,[4] "with some degree of certainty by the location of the older tubercles. If the bronchial or mediastinal glands show the earliest lesions, the infection probably came through the inspired air; but if the retropharyngeal, mesenteric, or portal glands have the oldest lesions, the infection was probably through contaminated food."

Mohler and Washburn continue:

Heredity.—"Hereditary transmission, or congenital tuberculosis in the offspring, is evidently more frequent in cattle than in man; nevertheless, it must not be regarded as an important cause of the genesis of tuberculosis, but rather the exposure to infection during post-fœtal life. Predisposing causes which arise from unsanitary conditions, lowered vitality, exposure, and forced development, etc., are only responsible for giving the true cause (*Bacillus Tuberculosis*)

Predisposing causes

1. 6th I. C. on T., Vol. 4, pt. 2, p. 631.
2. The British Royal Commission have also observed instances of lung filtration of bacilli introduced through the alimentary tract (Final Rept., p. 27).
3. Bureau of Animal Industry, U.S.A.
4. B. A. I., Bul. 38, p. 29.

an opportunity for lodgment and development, or better facilities for propagation in case the lesions are already present."

Bang[1] says, "It is not at all rare to find tuberculosis in a calf fœtus or in new-born calves. I have been interested in this question, and I have seen far more than a hundred cases of this kind. The infection came always from the mother, and the bacilli are introduced into the body of the calf through the umbilical vein. As a consequence, tubercles are almost always found in the lymphatic glands of the liver, and, as a rule, in the liver itself; next in the mediastinal glands and in many different organs (the lungs, the spleen, the heart, the glands of the shoulder and knee, and even in the mesenteric glands). Although the infection, as a rule, occurs early during the life of the fœtus (a five-months-old fœtus can already contain calcareous tubercles, and in new-born calves the tubercles, as a rule, contain lime), congenital tuberculosis has seldom attained a high development at birth, and the majority of such calves might very well have lived longer. They were not slaughtered because they were considered sick.

Congenital tuberculosis

"Although congenital tuberculosis is not particularly rare in calves, it is not sufficiently frequent to play an important part as the source for the dissemination of tuberculosis. Careful examination of slaughtered sucking calves in slaughter-houses in regions where tuberculosis is of very frequent occurrence, as in Aarhus (Denmark) and Kiel (North Germany), show that not more than 0·5 to 1 per cent. of the calves show signs of congenital tuberculosis. When we consider that the conditions for the infection of the fœtus are, either that there is tuberculosis in the uterus itself, or that tubercle bacilli circulate in the blood of the mother, and that this occurs only in very exceptional cases, unless the mother suffers from tuberculosis in a very advanced and generalised state, we know really in advance that there is actual danger of infection only in markedly tuberculous animals, and that the great majority of lightly infected cows may bear healthy calves."

According to the calculations of Klepp,[2] only 2·63 per cent. of the calves dropped by tuberculous mothers are affected with congenital tuberculosis.

"It would appear from these figures," Salmon concludes, "that possibly not more than 1 per cent. of the calves from tuberculous mothers are affected with tuberculosis at the time of birth. In very badly affected herds as high as 2 per cent. of the calves may have congenital tuberculosis. Under any circumstances it is plain that the great majority of calves contract the disease either from contaminated milk or from inhabiting the stables where tuberculous cows are kept."

The belief in the hereditary transmission of bovine tuberculosis

1. 6th I. C. on T., Special Vol., p. 210.
2. Bongert, J., Ueber die Art der Infektion bei der Tuberkulose der Haustiere. Read at Eighth International Veterinary Congress, Budapest, 1905. Quoted by Salmon, B. A. I., Bull. 38, p. 35.

is not by any means extinct, for we find Professor Sir John M'Fadyean devoting a masterly article in refutation of it in the 1910 issue of the Journal of the Royal Agricultural Society of England. Having dealt with such records as those quoted above, showing the small proportion of calves born tuberculous, he points out that the absence of lesions, even by the most searching *post-mortem* examination, being admitted, the more subtle argument of latency of bacilli in resistant tissues has been urged in support of the contention for hereditary transmission. (See the views associated with the name of Baumgarten, p. 134.)

"The answer to this contention," says M'Fadyean,[1] "has been furnished by numerous experiments, which show that when calves are infected with tubercle bacilli within a few days or weeks of their birth, visible disease develops in them with even greater rapidity than in older animals."

No evidence has ever been produced in support of the argument for latency of bacilli in resistant tissues which is [2]"....absolutely disproved by the evidence accumulated in recent years to show that when calves born of tuberculous cows are promptly removed from their dams and kept under conditions that prevent infection *after* birth, they do not become tuberculous."

The knowledge that the disease has an incubative stage (see p. 234) compels the admission that [3]"....probably some of the apparently sound calves of tuberculous cows are born infected, the infection having been of too recent a date to permit the development of visible tubercles. This, however, is the only sense in which latency can be admitted, and even when the fullest weight is allowed to it, it cannot be held that the fact seriously invalidates the conclusion based on the proved rarity of visible lesions in new-born calves."

[4]"The fact appears to be that the belief in the importance of heredity in the spread of the bovine disease was in large measure borrowed from human pathology, and was not a view naturally suggested by the observed facts in connection with animal tuberculosis."

The belief in hereditary transmission of the human disease has, as we have already seen, been almost abandoned by pathologists (see p. 136), and strangely enough this view was made highly improbable by observations regarding the bovine disease.

It has also been argued that the figures showing the number of calves born tubercular are fallacious, because [5]"....probably some tuberculous calves die or are killed in consequence of their weakly condition within a short time after birth," and such cases do not find their way into slaughter-houses, and consequently escape inspection. Professor Sir John M'Fadyean agrees that "This may be

1. Jour. R. A. S. E., 1910, p. 30.
2. Jour R. A. S. E., 1910, p. 31.
3. Jour. R. A. S. E., 1910, p. 30.
4. Jour. R. A. S. E., 1910, p. 28.
5. Jour. R. A. S. E., 1910, p. 29.

admitted, but it cannot be conceded that the number of cases of congenital tuberculosis that thus escape detection is sufficiently large to introduce any important error into the published statistics. . . ." although [1]" when one is devising measures for the eradication of the disease from a herd," account must be taken of the possibility that a new-born calf may be tuberculous, [2]". . . .and young calves that appear weakly and unthriving should be isolated until they can be tested."

[3]" A large proportion of the calves got by a particular bull may, before they reach maturity, be proved to be tuberculous, but since there are in almost every herd opportunities for infection after birth, this fact does not in the least justify the conclusion that these animals were born tuberculous, or that the sire was the source of their infection."

Infection of Calves by Tuberculous Milk.—" Pearson and Ravenel,[4] in treating of the ways in which tuberculosis may be spread, say that the mixed skim milk returned from a creamery to a healthy herd may be contaminated. This danger is so great that in some places (parts of Pennsylvania and New England, France, and Germany) it is the practice to heat skim milk to a temperature that will ensure the destruction of the tubercle bacillus. In Denmark and Prussia such heating of skim milk and buttermilk is required by law. Several illustrations of this danger had recently come under the observation of these authors. In one case a large herd was tested with tuberculin and found to be extensively diseased. Two of the cows had tubercular udders. This herd was used for the production of cream that was shipped to market, the skim milk being retained for feeding calves. It was the practice on this farm to remove the calves from their dams when they were three days old and keep them in a separate building distant from the cow stable. The dairy building and separator were located midway between the cow stable and the calf stable. After the cream had been separated, the skim milk was carried on for the calves. When the cows were tested, the calves were also examined, and it was found that while the prevalence of tuberculosis among the dairy cows was 75 per cent., all the calves reacted and were condemned. The *post-mortem* examinations of the calves revealed tuberculosis of the postpharyngeal lymphatic glands or lower digestive tract in all cases, indicating that infection had occurred through the digestive system, and that it had been carried to these calves in skim milk."

Mode of Infection

Salmon[5] also quotes the observations of Phelps,[6] of the Storrs (Conn.) Experiment Station : " During the greater part of the four years that four tuberculous cows were at the station, the milk of some

1. Jour. R. A. S. E., 1910, p. 31.
2. Jour. R. A. S. E., 1910, p. 44.
3. Jour. R. A. S. E., 1910, p. 32.
4. Pennsylvania Dept. of Agri., Bull. 75, cited by Salmon, B. A. I., Bull. 38, p. 34.
5. B. A. I., Bull. 38, p. 36.
6. Storrs Agri. Exp. Sta., Bull. 23, pp. 9-20.

or all of them was fed to calves. The results of the first two years' feeding show that, while the milk of each of the four cows was fed to several calves in periods ranging from three months to one year and four months, in no case was there any indication of disease in the calves during the feeding period. The calves were kept with the cows nearly two years. One of these calves responded to the tuberculin test about five months after the feeding period of sixteen months was ended, and was found upon *post-mortem* examination to be very slightly diseased.

Milk infection

"Two calves, the offspring of tuberculous cows, were selected for a comparison of the infectiousness of Pasteurised and raw milk. About half of the milk of one cow was heated to about 170° Fah. and fed to her offspring, and the balance of the milk in its natural state was fed to the offspring of the other tuberculous cow. The calves were isolated from the cows. Neither of the calves responded to a tuberculin test made after a feeding period of about ten months. By a misunderstanding both of the calves were fed the un-Pasteurised milk of the cow for a period of three weeks (following the tuberculin test), after which they were turned out to pasture for about five months. Three weeks after being returned to the stable with the cows the calf which had been fed the Pasteurised milk (except for three weeks) responded to the tuberculin test, while the other calf failed to respond until five months later.

"Two other calves were fed the milk of their dams from August and September, 1898, until the next June. At the end of ten months' feeding in one case and nine and one half in the other neither of the calves responded to the test. One calf was at pasture from June 24th to November 13th, while the other remained in the stable with the cows. Both responded to the test on December 2nd following, three weeks after one of the calves was returned from the pasture.

"Two more calves were fed the milk of the two other cows. Both had tuberculous mothers. One was kept in the stable with the cows, and after being fed the milk of cow No. 1344 for a period of ten weeks responded to the tuberculin test. The other was fed the milk of its dam (No. 1343) while isolated in a room in another part of the barn. After a feeding period of nearly three months this calf responded to the tuberculin test.

"Three other calves from non-tuberculous cows were selected early in May, 1900, and placed in a small pasture near the station barn. Calf L was fed the milk of No. 1337, Calf M the milk of No. 1341, and Calf N the milk of No. 1343. All practicable precautions were taken to prevent the transmission of the disease in any way except by the milk. The calves were tested May 24th and 25th, about three weeks after the feeding began, and again September 28th and 29th, after having been fed over four and one half months. None of the calves responded to either test. The calves were not fed milk after the September test, but were kept isolated from the cows. Calf M died November 29th, and an examination by the station veterinarian revealed a congested condition of the stomach, kidney, and bladder, indicating some form of poisoning. An examination of the lungs also demonstrated the existence of tuberculosis, there being a tuberculous nodule in the right lung, calcified, and the mediastinal lymphatic being tuberculous. The two remaining calves failed to respond to a tuberculin test in February, 1901, and in May were sent to pasture with some other stock. Thus, in the first feeding test one calf out of several became tuberculous, and in the four succeeding tests seven out of nine eventually became tuberculous. The two which did not respond to the test may or may not have been diseased. The uncertainty of depending upon repeated tuberculin tests in such cases is shown by the last-mentioned experiment, in which no tuberculosis would have been found had it not been for the accidental death of one of the calves. Some of these calves may have been infected through cohabitation, but in any case the large proportion of infection shows the danger of having tuberculous cows in a herd."

Open tuberculosis

Spread of Infection among other Cows.—Delépine[1] concludes ". . . . that cows in a state of advanced tuberculosis, and *emitting discharges loaded with tubercle bacilli*, constitute the chief factor determining the distribution of bovine tuberculosis."

The term "discharges" denotes in this case not only urine and fæces, but also sputum, vaginal secretions, and milk; in short, all materials voided by the animals.

Cows in coughing spray their sputum on surrounding objects and thus infect one another.[2] This affords one reason why hay contaminated with the dust from stables inhabited by tuberculous cattle is dangerous for healthy animals.[3]

Von Behring[4] states "It is absolutely impossible to determine all the numerous ways in which tubercle bacilli coughed up, or otherwise scattered about by the tuberculous animals, will finally reach the organism of the other cattle in the stable; and I regard it as almost impossible, by means of mechanical or other measures, to prevent the spread of virus from a case of open tuberculosis to the other inmates of the same room."

We have already referred to Schroeder's[5] conclusion that "A single tuberculous cow that is passing the bacilli in her fæces will infect a whole stable sooner or later."

Schroeder and Cotton[6] made experiments to test the rapidity with which tuberculosis spreads in a stable from diseased to healthy cattle. Salmon[7] summarises this valuable work as follows:—

1. Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 239.
2. Tendeloo, 6th I. C. on T., Vol. 1, pt. 1, p. 88.
3. Salmon, B. A. I., Bull. 38, p. 80.
4. The Suppression of Tuberculosis, trans. by Bolduan, p. 82.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 737.
6. B. A. I., 20th Annual Rept., pp. 61-8.
7. B. A. I., Bull. 38, p. 37.

"Seven healthy cattle and three tubercular cows were confined in a stable containing ten box stalls, which were separated by solid 2-inch plank partitions 6 feet high. Five of the healthy cattle and the three tuberculous cows occupied different stalls each day, in a rotation which exposed each of the healthy cattle equally to the three diseased cows. Two of the healthy cattle occupied stalls near the centre of the stable and were at no time allowed to enter other stalls or to come into closer contact with any of the other cattle.

Stable infection

"Two and one half months after the beginning of the experiment one of the three tuberculous cows was removed from the stable, and two other and more severely affected cows were introduced. One of these tuberculous cows died after it had been in the stable two months, and was found to be affected with generalised tuberculosis, but without disease of the udder or lymph glands associated with or near the udder. All of the exposed cattle were tested with tuberculin at the beginning of the experiment and found to be free from tuberculosis.

"The experiment began January 27th, 1903, and the exposed cattle were tested with tuberculin on June 30th following. The two animals which had been confined to their stalls were a yearling bull, which reacted to the last test, and a six-year-old cow, which did not react. Both animals were found tuberculous when killed and examined August 3rd, 1903. In the bull the posterior mediastinal glands were slightly enlarged and contained numerous small recent foci of tuberculosis. The anterior mediastinal glands were greatly enlarged and filled with foci of tubercular material, and the bronchial glands contained several small foci of recent tubercular disease. The cow also was diseased, having several of the mediastinal glands greatly enlarged and thickly sprinkled with small tubercular nodules, recent in character, and, in addition, several small recent areas of tubercular disease scattered through the lung.

"Two heifers, one six months old and one eighteen months old, both in good condition, were made to occupy a different stall each day in order that they might be exposed equally to each of the tuberculous cows. When tested with tuberculin on June 30th both reacted. *Post-mortem* examination of the younger animal showed the left principal lobe of the lung adherent to the chest wall, and near the adhesion a tuberculous nodule in the lung tissue about 1 inch in diameter. The anterior and posterior mediastinal glands, the bronchial glands, and the lymph glands about the root of the tongue were greatly enlarged, and either entirely tubercular or thickly sprinkled with minute tubercular foci. Several of the mesenteric lymph glands were converted to the extent of half of their substance into tubercular material, and a number of other mesenteric glands were affected, as were also the glands at the brim of the pelvis in the abdominal cavity. The lesions were all of comparatively recent origin. The older heifer had one small focus of tubercular disease in the left principal lobe of the lung, and sprinkled over various portions of the pulmonary pleura of the right principal lobe of the lung were numerous tubercles with corresponding tubercles on the costal pleura. The pulmonary surface of the diaphragm was sprinkled with numerous small tubercles, and the various lobes of the lung were adherent to each other and to the diaphragm by means of tissue containing many tubercles. The appearances were typical of pearl disease in cattle.

Salmon[1] points out that " The rapidity with which tuberculosis spreads in stables occupied by tuberculous cattle is shown with particular emphasis by the two cattle which became tuberculous without actual contact with the tuberculous cows and while standing in stalls which were separated from the other stalls by solid partitions six feet high. The distribution of the lesions indicate that the germs of tuberculosis in stable infection are more commonly respired than ingested with food. This experiment clearly shows that cattle cannot be protected from tuberculosis when in the stables with tuberculous cattle, even when each animal is carefully restricted to its own individual stall."

Effect of bad stabling

" Dr. Leonard Pearson[2] has made interesting investigations bearing upon the effect of bad stabling conditions in favouring the spread of tuberculosis among cows. For the purpose of the investigation two herds were established of six cows each. Four in each herd were healthy and two in each herd were tubercular. One herd was kept in a roomy, light, clean, and well-ventilated stable. The stalls and partitions between the mangers in this stable were so constructed that the cows were kept apart from each other.

" The other stable was small, close, poorly ventilated, rather dark, and not especially clean. The cows here were not separated by stall partitions, and they were all fed from the floor of the passage way in front of their stalls.

" This experiment continued for 513 days, or about 17 months, and at the close it was found that two of the originally healthy animals kept in the large light stable had contracted tuberculosis, and the other two of the originally healthy cows continued sound. Of the four originally healthy cows in the small dark stable, all had contracted tuberculosis. The progress of the disease in each infected animal in the dark stable was greater than in the infected animals in the light, airy stable."

Tuberculous dust, etc.

Mohler and Washburn[3] consider that " Irrespective of the view that may be taken relative to the elimination of tubercle bacilli from the bodies of tubercular animals in their secretions from unaffected organs, it must be admitted that the chance for the introduction into these secretions, or into the secretions of healthy animals in the same environment, of infected material, such as particles of soiled forage

1. B. A. I., Bull. 38, p. 38.
2. Penn. Dept. of Agri., Bull. 74 ; summarised by Salmon, B. A. I., Bull. 38, p. 41.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 630.

or bedding, dust, masses of mucus which have adhered to the skin, hair, etc., is a very great danger decidedly of too much importance to be ignored."

Cattle licking

"The habit which cattle have of licking each other is sufficient to account for the occurrence of tubercle bacilli in the milk of a healthy cow into which some of her hair or scales of epidermis have fallen after she has been in contact with a cow affected with tuberculosis of the respiratory organs, while of still greater importance must be considered the possible contamination of such milk by particles of infected manure in the form of dust, dirt, etc."

Schroeder's experiments on room exposure of guinea-pigs in cow stalls are referred to on p. 15.

Infection paramount

Deering[1] relates: "In eighteen months, through the introduction of a diseased animal (one that did not show the physical evidences of the disease when purchased), a herd of 26 animals that were tested and found sound were infected so that 24 out of 26 were condemned, and all but one plainly showed the disease upon *post-mortem* examination. This herd was under the very best of hygienic surroundings—all that money could buy or ingenuity could suggest. Very many similar cases I could quote, but if the few will not suffice, the many will not convince."

That ingestion is an important mode of infection of tuberculosis is indicated by the infection of swine.

Dawson[2] reminds us that statistics "....show that the disease prevails in swine in proportion as they come in contact with infected cattle. In fact, swine tuberculosis is now taking high rank as the most important swine disease which may affect the public health. In swine the disease is usually generalised, and thus more edible portions of the carcass consumed, and the chances of infection are to this extent increased.

"Porcine tuberculosis is found most prevalent in hogs fed on dairy refuse from infected dairy cattle and where they have access to cattle manure. That swine readily contract tuberculosis from the ingestion of artificially infected milk, from feeding behind cattle affected with natural tuberculosis (see p. 117), by drinking artificially infected water, and by the subcutaneous injection of virulent tubercle bacilli, has been demonstrated by Schroeder and Mohler, of the Bureau of Animal Industry."

Interchange of cattle

According to Moore,[3] "A careful inquiry into the extent and distribution of bovine tuberculosis shows that it is most prevalent in those districts where there has been the greatest interchange of cattle. As its dissemination depends largely upon the introduction of infected individuals, it was not strange that with an unrestricted

1. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 736.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 918.

cattle traffic many infected animals were innocently bought and sold, thereby carrying the disease and spreading its virus. The usual slow development of tuberculous lesions in cattle, and the fact that many infected individuals are spreading the bacilli before their true condition is suspected, made it possible for a large number of herds to become extensively diseased as a result of the increase in cattle traffic caused by the constantly growing demand of our large cities for milk."

"The rapid and widespread dissemination of the disease by the sale of breeding stock from tubercular herds has been pointed out by Russell and Hastings.[1]

"Where the disease establishes itself in herds that are sold for breeding purposes the danger is much increased, for animals from such sources are much more apt to be widely disseminated, since they generally serve as a foundation for the breeding up of common stock. The State of Wisconsin, as well as other North-Western States, has suffered in this regard very severely from some of its finest breeding herds. One herd in particular in this State has had anything but an enviable record in this matter, for it has been determined that tuberculosis has broken out in at least sixteen herds to which members of this original herd were sold. While it cannot be proved that the origin of the disease in each of these sixteen cases could be traced to the animals originally purchased, yet it is noteworthy that in a considerable number of cases the first animals to show evident symptoms of the disease were those that were introduced from this badly diseased herd. Not only were a number of fine herds in Wisconsin infected from this source, but the contagion was also spread, in a number of cases, to Minnesota and Iowa."

[2] "Report of Committee on Dissemination of Bovine Tuberculosis.

"*(International Commission on the Control of Bovine Tuberculosis.)*

"The sub-committee on the dissemination of bovine tuberculosis respectfully submits the appended report on the means for the dissemination of this disease, based on the present knowledge of the life history of the tubercle bacillus. The possible means for the dissemination of this disease are enumerated as follows :—

"(1) The introduction into a sound herd of an animal or animals affected with tuberculosis : (*a*) those with open tuberculosis, (*b*) those in which the disease is in a period of incubation, and (*c*) those in which the lesions are temporarily arrested,

"The last group will not transmit the infection speedily and

1. Wis. Agri. Exp. Sta., Bull. 84 ; summarised by Salmon, B. A. I., Bull. 38, p. 37.
2. Rept. Int. Com. on C. of B. T., p. 24.

possibly may never do so. The first group is certain to spread the virus.

"(2) By feeding calves milk, whole or separated, buttermilk or whey, where the milk has come from tuberculous cows.

"(3) By bringing cattle suffering from open tuberculosis in contact with healthy ones at fairs, cattle shows, and other exhibitions.

"(4) By shipping healthy cattle in cars not thoroughly disinfected, recently occupied by tuberculous cattle.

"(5) By placing healthy cattle in stables that have not been thoroughly disinfected and which were recently occupied by tuberculous animals, as frequently happens with the change of farm ownership or tenants.

"(6) Tuberculous animals which do not react to tuberculin, such as those in the period of incubation or latent cases, but which develop active tuberculosis later, are frequently carriers of the virus although bought and sold as sound animals. These cannot at present be differentiated from sound animals. Therefore, all cattle coming from herds in which the disease exists should be considered as suspicious. The sound herd is the unit to deal with.

"(7) Tubercle bacilli may be transmitted by tuberculous cattle running in a pasture to healthy cattle in adjoining pastures where they are separated by a fence of such nature that the cattle may get their noses together.

"(8) Tuberculosis in cattle rarely, if ever, occurs through infection from (*a*) man, either directly or as a carrier of bovine tubercle bacilli; (*b*) from other species of animals, or (*c*) by infection from the droppings of crows, buzzards, or other birds or carnivorous animals that have fed upon the carcasses of tuberculous cattle. It is the opinion of this committee that bovine tuberculosis is spread largely through the introduction of tuberculous cattle into sound herds; by the feeding of calves with infected milk, or milk products; by exposing sound animals to infected ones at fairs, or other cattle shows; and by exposing them to infected cars and stables. There are other ways in which now and then it is possible that an animal may become infected, but the means of dissemination mentioned in this paragraph are those to be guarded against in formulating efficient methods of control.

"(Signed) V. A. Moore, *Chairman.*
"E. C. Schroeder.
"M. P. Ravenel."

RATS SPREAD INFECTION.

Noack[1] found that rats carried tuberculous material from slaughter-houses "....into the corn cribs of the farmer and troughs of his cattle."

A. M. Trotter, M.R.C.V.S.,[2] Chief Veterinary Inspector of the

1. 6th I. C. on T., Vol. 4, pt. 2, p. 988.
2. See The Scottish Farmer, Jan. 28th, 1911, p. 79.

City of Glasgow, refers to the "....incomprehensible practice of feeding pigs with slaughter-house refuse."

It is reassuring to find that, according to the British Royal Commission,[1] "The rat and mouse are highly resistant to the subcutaneous inoculation of the bovine tubercle bacillus, but after intraperitoneal inoculation, the tendency is for the bacillus to multiply in the body and to be present in large numbers in the organs, even in the blood, without causing the formation of tuberculous lesions such as are produced in animals susceptible to the bovine tubercle bacillus."

We may also mention in passing that, according to the same authorities, the dog is highly resistant to the subcutaneous inoculation of the bovine tubercle bacillus.

In this connection it is fortunate that Dr. Danysz has discovered the causal micro-organism of a rapidly fatal disease in rodents—a disease to which domestic animals are not susceptible. Cultures of this organism are now well-known commercial commodities. An interesting instance of the efficiency of these cultures is afforded by the extermination of rats from the small islet Ailsa-Craig, at the Firth of Clyde, Scotland.

Simpler and less expensive, though probably less efficient, measures are described in Circular No. 9 of the Public Health and Marine Hospital Service, U.S.A., which we reprint in full by kind permission of the Surgeon General. (See Appendix D, p. 446.)

PASTEURISATION OF FACTORY SKIM MILK.

[2]"The States of Iowa and Minnesota have enacted laws requiring each creamery management within their jurisdictions to Pasteurise all skimmed or separated milk from their establishments before returning it to the farm patrons."

The same is true for Denmark, and, according to Jensen,[3] "It is conclusively established that the obligatory Pasteurisation of skim milk in the various creameries, that has been adopted in Denmark in recent years, has greatly aided in checking the spread of tuberculosis among swine and calves."

Bang[4] and Newsholme[5] confirm this.

An interesting example of the value of Pasteurisation of separated milk for pig feeding is to be found in the Annual Report of the Veterinary Inspector to the New Zealand Government, as follows :—

Tuberculosis in pigs

[6]"The measure most immediately necessary is the compulsory heating to a temperature high enough to render tubercle bacilli innocuous of all separated milk and whey at dairy factories and creameries. This has been strongly advocated in previous reports,

1. Final Rept., p. 5.
2. Mohler and Washburn, 6th I. C. on T., Vol. 4, pt. 2, p. 637.
3. Milk Hygiene, p. 74.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 864.
5. The Prevention of Tuberculosis, p. 145.
6. Ann. Rept. of the New Zealand Dept. of Agric., 1909, p. 102.

and I would once more emphasise the necessity for it. As I have pointed out in a special report already furnished, this would undoubtedly reduce the number of tubercular pigs by at least 80 per cent., and probably 90 per cent., and, moreover, would have a markedly beneficial effect in checking the spread of the disease among cattle, by removing the fertile source of infection now provided by the rearing of calves upon separated milk or whey containing tubercle bacilli. A striking object-lesson in the value of this measure is afforded by the experience this year of a large dairy farmer in this country, who deals with the whole of the milk yield of his cows in his own factory. Though a good farmer and a careful breeder, he has been unlucky enough to have had extensive tubercular infection among his cows for several years past. His experience last year with pigs fed on the separated milk derived from his cows was detailed in the last annual report. For the purpose of comparison, the figures concerning this are repeated below. This year he installed a plant for Pasteurising his separated milk before feeding it to his pigs. He obtained a Pasteuriser, but, unfortunately, this, owing to the ineffectiveness of the factory boiler, did not give satisfaction in working, and it was removed, a system of heating the milk by direct steam being substituted. This did not enable him to raise the temperature to the standard accepted as necessary for Pasteurisation with proper appliances—viz. 176 deg. Fahr.—but, on the other hand, it was held at a lower temperature for a considerable time. Even with this inadequate appliance, the results have been most startlingly gratifying. Note the comparative figures :

"Number of Pigs killed on certain occasions.		Number found Tubercular.	Percentage Tubercular.
1907-8.			
(1)	63	39	61·90
(2)	110	65	59·09
(3)	50	50	100·00
1909			
Jan. 20	28	*3	10·70
Feb. 23	36	0	0·00
Mar. 23	40	0	0·00

* Two very slightly affected.

" These figures speak eloquently for themselves. All these pigs were, as before, examined at the time of slaughter by Government inspectors, and previous to slaughter had been bred, housed, and kept under exactly the same conditions as in the previous year."

RESULT OF NEGLECT.

"I will speak of only one herd," says Deering,[1] "consisting of 175 head. Eight years before it was destroyed it was tested, and 25 per cent. reacted. In five years it was re-tested and 75 per cent. reacted. In three years more it was re-tested and 100 per cent. reacted, and they were all destroyed." This is ". . . . a fair example," says Deering, "of what is going on in other herds where tuberculosis is allowed to remain."

AVOID VACILLATION.

"If experience teaches us anything," says Pope,[2] "it teaches us that sporadic, vacillating, penny-wise combating of the disease exasperates the farmer, wastes the money expended, and makes the ultimate stamping out of bovine tuberculosis increasingly difficult."

That animal tuberculosis is on the increase, notwithstanding the efforts for its suppression, is ascribed by Pope to two causes: ". . . . measures for combating the disease have been ill considered or inadequate, or have proved abortive from failure to win the farmers' co-operation and support, upon which must ultimately depend the success of our crusade."

The failure of the Bang method, tried in Belgium under Government support, is ascribed by Heymans[3] to its difficulty and carelessness on the part of the stock owners in the execution of the system.

Deering[4] says that "No State will ever be successful in eradicating tuberculosis by a mean cheese-paring policy."

TUBERCULIN TEST FOR SHOW CATTLE.

Lawson's advocacy

Councillor Edward E. Lawson, of Leeds, England, has advocated the desirability of this procedure for years, and recently has succeeded in securing recognition for the suggestion. Our friends on the other side have also awakened up to it. In speaking of the discouragements to the farmer in the States to clean his herd, Pope[5] says, "Though led to believe that the disease is highly contagious, he sees feeders and cattle for show purposes exempted from the test to which cattle for breeding and dairying are subjected; yet he knows that many of these feeders are worn-out dairy cows, which are shipped to the city to be sold to farmers and by them turned into beef. That such feeders are scattering the disease into non-dairying districts is a well-known fact. The wisdom of the policy of exempting show cattle from the test is, as far as its effect upon stamping out of tuberculosis is concerned, extremely doubtful."

Dyson's views

Dyson[6] asks: "What can be said in favour of a pure bred cattle

1. 6th I. C. on T., Vol. 4, pt. 2, p. 914.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 522.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 578.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 515.

breeders' association, organised ostensibly for the purpose of improving or maintaining the purity of a breed, which will permit the registration of animals from herds known to be affected with tuberculosis, thereby advancing the cause of tubercular infection ? and why do most of these associations oppose all efforts on the part of progressive States and the Federal Government to enact laws by which this disease could be eradicated ?

[1]" What can be said in favour of the management of State fairs and live stock expositions, which are supposed to encourage the advancement of live stock interests, when premiums in the cattle classes are awarded indiscriminately to diseased and healthy animals, and no precautions taken to protect a healthy animal from becoming infected with tuberculosis by being exposed to those which are diseased and unfit for any purpose other than deceptive exhibitions of merit ? How can live stock interests be advanced by the awarding of prizes to tuberculous animals, when a tuberculin test and a certificate of health would prevent such a common infraction of justice ?

" In contrast to the above-mentioned facts as they prevail may be asked : Why is it that horses with a slight physical defect, such as a splint, are rejected at such expositions in favour of sound animals of otherwise less merit ? Simply and solely for the reason that the defect is apparent to even the casual observer, and affects to a certain degree the market value of the animal.

" To judge cattle by the same standard, it is admitted by the managers of live stock expositions and others well informed, would result in excluding fully 50 per cent. of practically all pure bred herds from participating in such shows. How long such deception will be permitted to last in the face of its economic status can only be surmised."

Nocard[2] records that " In 1892 the prize beast of the pretty town of Marmande had to be condemned on account of general tuberculosis ; it had won 800 francs ! "

Pope[3] tells us that "....at the recent International Fat Stock Show, the steer which had been fed by one of our leading agricultural colleges[4] and which surpassed all former records and brought the highest price after passing all the experts, was, on *post mortem*, found to be so badly infected with tuberculosis that the carcass was unfit for food." A bad case

Councillor Lawson points out, says The Veterinary News,[5] ".... the prize is given for the *best* animal of that type—*best* in all discoverable directions. It is, unfortunately, possible for the best-looking ox in a show to be affected with tuberculosis, but it is surely a mistake for such an animal to be credited with being the *best* animal there when there are others, inferior in looks, it may be, but free from disease.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 516.
2. The Animal Tuberculoses, p. 36.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 576.
4. In America.
5. The Veterinary News, Dec. 25th, 1909, p. 631.

Such an affected animal—say a bull—is not the best for other breeders to use for their cows; or such an affected cow is not the best to buy as a foundation of a herd. The suggestion is that cup and breed prizes should only be awarded to animals which have recently passed the test.....Such a scheme will add yet another incentive for the private owner of pedigree stock to eradicate tuberculosis from his herd, and without this private endeavour a State scheme would have little chance of success. Veterinary surgeons would do well to suggest Mr. Lawson's scheme to their local societies, not for all the cattle classes, but for one or two as a commencement. We believe the effect could be only for good."

Mr. Lawson succeeded in impressing his views on the organisers of the Yorkshire Show[1] in 1910. Prizes were duly awarded for the best non-tuberculous animals, and it is to be hoped the proposal will receive wider recognition in future.

Coni[2] tells us that in The Argentine "Animals are not admitted to the exhibitions from establishments where tuberculosis has been proved to exist."

It is interesting to note that the International Commission on the Control of Bovine Tuberculosis, 1910, adopted a resolution on the lines we are discussing (see p. 317).

BUILDING UP A HEALTHY HERD.

"The work in New York State has pointed out very clearly," says Moore,[3] "the danger of building up herds with non-reacting individuals taken from herds in which there is a greater or less amount of tuberculosis. The sound herd, rather than the non-reacting individuals, should be sought for by the purchaser. This will require more attention to breeding and less indiscriminate buying of cattle. The essential facts that have been elicited from the results of our work, and which we have found to be important in the control of tuberculosis in individual herds, may be summarised as follows:—

"(1) The cattle should be tested with tuberculin, subcutaneous injection, and all of those giving a reaction should be removed. The reacting animals should be either destroyed, slaughtered for beef under proper inspection, or kept for breeding purposes, after the Bang method. The choice of procedure must depend upon existing conditions.

"(2) The herd should be re-tested at intervals of from six months to a year, and all reacting animals promptly removed.

"(3) Cattle for dairy or breeding purposes should be bought from sound herds only.

"(4) Animals that have once reacted should not be placed with sound cattle, although they may cease to react and remain well to all appearances.

1. See The Yorkshire Post, July 28th, 1910.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 61.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 923.

"(5) Milk from cows of uncertain health should not be fed to calves unless previously sterilised.

"(6) It is desirable that the owners keep a record of the tuberculin tests of their cattle made by competent veterinarians. Such a record of each animal is a valuable asset.

"(7) The application of tuberculin should not be trusted to unskilled persons.

"(8) In eradicating tuberculosis, the individual herds are the units to deal with, and their owners must be held responsible for them."

ADVANTAGE OF SMALL HERDS.

The small farmer may take much consolation on this score, for the evidence is very convincing that he has a much better chance of maintaining the purity of his animals than the man in a big way. In reference to the examination of herds in California, and after discussing the large herds, Ward and Haring[1] state: "When we come to a consideration of the results of tests of groups of five cows or less, the results are more satisfactory. Of 71 animals, only six (8 per cent.) reacted. The most of these cows were kept in Berkeley and pastured in vacant lots, restrained by a rope and stake. We believe that most of them had been raised under these conditions or in small isolated country herds. This practice of keeping cows represents the extreme to which animals may be isolated, and likewise presents the minimum of tubercular infection. The extent to which animals are associated with others seems to be the determining factor. Cows isolated show a low percentage of tuberculosis, while those crowded together in large herds show a high percentage."

The following figures are given:—

Herd No.	No. of Cows.	No. reacting.
12	17	1
13	17	3
15	5	0
18	10	0

The figures for larger herds in the same district will be found on p. 196.

Russell and Hastings[2] state that "A large herd is more often affected than a small one because the opportunity for introducing a diseased animal into the herd is dependent on the number of animals purchased."

REAR YOUR OWN CALVES.

Klein[3] tells us that in Pennsylvania those ". . . . portions of the State where cattle were raised in sufficient numbers to meet local needs and into which few cattle were shipped were entirely free from the disease."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 566.
2. Wis. Agri. Exp. Sta., Cir. of Information, No. 23, p. 3.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 556.

On the other hand, Brittlebank[1] states, in reference to the conditions he found around Manchester, that in the "....districts where tuberculosis is most prevalent there are many old farms, and that much of the cattle is bred on the premises."

Evidently it is a question of infection. The progressive and enterprising breeder will regard it as a matter of getting rid of the disease and keeping rid of it; when, as Salmon[2] points out, "It should be remembered that tuberculosis is a very common disease, especially among dairy cattle, and that it is a difficult matter to add new animals frequently to a herd and at the same time avoid the introduction of this disease. A herd free from tuberculosis should, therefore, be renewed and increased by its own offspring so far as possible. To bring in animals from other herds, either temporarily or permanently, is to accept a risk that may prove disastrous."

We are here confronted with the difficulty which many milk producers experience in rearing their own calves. Professor C. O. Jensen, of Copenhagen, has devoted many years of patient earnest labour to the study of this problem. An account of his work will be found in Appendix C (p. 432).

1. Quoted by Delépine, 38th Annual Rept. L. G. B., p. 392.
2. B. A. I., Bull. 38, p. 81.

CHAPTER VII.

PLAN OF CAMPAIGN.

HOPELESSNESS OF LEGAL METHODS.

ALL authorities who have inquired into and thought about the problem of bovine tuberculosis are convinced that it is a colossal one, but it is equally evident that it must be dealt with. The question is how. We shall endeavour to sift out and consolidate the soundest and most practical views into a definite line of action for our own country. It seems clear that from the technical point of view the eradication of the disease is quite practicable, but [1]" Little can be said in favour of knowledge unapplied, as evidence of knowledge depends alone upon its practical application; therefore, unless the well-known and time-proved methods of successfully dealing with the question of eradicating tuberculosis can be applied now, the question of economics involved will later assume such huge proportions as to practically eliminate any further thought of eradicating the disease in animals, in proof of which the prevailing conditions in some of the European countries with reference to the disease may be cited as a logical sequence.

Radical steps

" History conclusively proves that no advance steps towards signal accomplishments in the matter of public health or the future welfare of the human race have ever been taken except by those who, at the time of the initial movement, were considered radical; therefore, inasmuch as history, in order to be progressive, must repeat itself, no progress can or will be made toward the eradication of tuberculosis until radical steps are taken—after which conservatism will find its place."

Legislative principle

Legislative means are now in operation in the United States, and although apparently making some headway, they are slow. The coercive or legislative principle does not appear equal to dealing with so large a problem. The American experts, as a whole, are not very sanguine over their results.

In the discussion which followed the reading of Hess's paper at the Sixth International Congress on Tuberculosis, Dr. Magill[2] showed that Hess's work had revealed a worse state of things in regard to the extent of tuberculosis in New York milk than he, Magill, had found seven years previously, notwithstanding the adoption in the meantime of a system of inspection, tuberculin testing, and similar

1. Dyson, 6th I. C. on T., Vol. 4, pt. 2, pp. 517-8.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 531.

sanitary measures. "After at least two years of this publicly proclaimed efficient control of the New York City Board of Health, Dr. Hess shows you," said Magill, "16 per cent. of the milk of that city to be contaminated with tubercle bacilli." Dr. Magill had found 10 to 11 per cent. seven years previously, and asked for an explanation of the increased infection.

Dr. Moore was unable to explain the figure, but maintained that progress had been made.

Even in famous Minnesota Dr. Reynolds,[1] of the Experiment Station, is not content with their progress.

In reference to his own and several other States which are doing a considerable amount of tuberculin work, he says that, as the small boy expresses it, they are "not getting anywhere." "There is no finality about it. We are not getting to the end of the road."

"Up to the present (1908)," Reynolds says, ". . . . the work has not usually been conducted on any comprehensive or well-organised plan that can possibly lead to eradication or to a positive control."

Dr. Eastwood[2] was unable to come to a conclusion regarding the progress made in this State, though he did not fail to notice the ". . . . desire to enhance the reputation of Minnesota as a State possessing a large number of tested and healthy cattle."

Eastwood's observations

[3]"In recording the information which I have obtained from America," says Eastwood, "I have given prominence to what seem encouraging features in the problem, and from these it would appear that under specially favourable conditions, where the farmers are enterprising, well informed, and prosperous, where the country is comparatively new and thinly populated, and where the proportion of infected to healthy animals is relatively low, areas of considerable size may become eventually free from the disease. But, regarding the conditions of the country as a whole, the general outlook is not hopeful. The disease is so widely disseminated, and the economic obstacles to its elimination are so excessively great, that it is impossible, even by a generous interpretation of the efforts which are being made, to put together tangible evidence of substantial success on the lines which have hitherto been followed.

"Tuberculosis progresses so insidiously, persists so long before manifesting its presence by physical signs, and has taken so firm a hold on the stock of the country, that there is not the least hope of being able to stamp it out by the application of any simple and drastic measures which have been effective in eliminating other infectious diseases. This, I consider, is the first lesson to be learnt from the disappointing results which have attended some of the American schemes.

"*It is, so far as my observations enable me to speak, useless to*

1. 6th I. C. on T., Vol. 4, pt. 2, p. 928.
2. Dr. Eastwood's Rept., p. 18.
3. Dr. Eastwood's Rept., p. 20.

attempt the formulation of any general plan for the complete eradication of bovine tuberculosis throughout this country (U.S.A.) within a limited period."

" Aggressive programmes of milk reform," says Eastwood,[1] " have not succeeded in America, and are not to be recommended."

[2]" Actual reforms are mainly due to the acceptance of reasonable recommendations offered by the Medical Officer, and are attributable to the recognition rather than to the exercise of this officer's right of direct intervention."

[3]" It is a well-known fact that any voluntary method of suppression by the herd owners themselves would bring about better and quicker results than when compulsory measures are enforced upon them by legislative enactments. Nevertheless, the time has arrived when a campaign, looking towards the control of the disease, should be entered upon by the general Government as well as the State and province."

INDIVIDUAL EFFORT.

In reference to the progress of eradication depending upon tuberculin testing, Reynolds[4] says, " For a study of the amount of eradication work being done by any of the States that are leading in this work, suppose we take Wisconsin, with her 3,240,000 cattle—not as a criticism, nor even as a special study of Wisconsin, but as a general study. Nor does this study of Wisconsin work....take into consideration the splendid and absolutely necessary work in these and other States in the way of educating and arousing public sentiment.

" At the rate of testing done this year, including the unofficial tests [two-thirds of the total (see p. 229)], we have about 41,000, the highest record for one year. By process of simple division we find that about eighty years would be required to test once all the cattle in the State, and one test accomplishes very little toward eradication."

Thirty-five years to test in Wisconsin

[5]Confining the calculation to the testing of the breeding herds and dairy cattle, 1,464,800 head, thirty-five years would be required at the present rate of testing.

[6]" A hasty survey of the figures for work in Minnesota, as in other of the few States that are doing considerable work with tuberculosis, gives the impression that the State is doing a great work ; and so it is when we consider that as such problems and movements go, this work is young. But when we consider work already accomplished or that can possibly be accomplished by our present methods

1. Dr. Eastwood's Rept., p. 78.
2. Dr. Eastwood's Rept., p. 47.
3. Rept. of Committee on Disposition of Tuberculous Animals (Rept. Int. Com. on C. of B. T., p. 25).
4. 6th I. C. on T., Vol. 4, pt. 2, p. 930.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 931.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 938.

One hundred and eleven years for Minnesota

and funds in the light of the entire problem, the amount of work done in Minnesota is trivial. At the present rate of 27,216 cattle tested officially last year (1907) it would require about twenty-four years to test the dairy and breeding herds alone, or one hundred and eleven years to test all the cattle in the State."

In this country we are not in a very particular hurry regarding the suppression of tuberculosis, but if the testing alone of our cattle would occupy a lifetime, and cost so much money as indicated, it is clear we need not look for a rapid elimination of the disease, and in the present state of public knowledge on the matter neither may we expect the State to grapple effectually with the problem. We must mainly depend upon ourselves.

Pennsylvania

Reynolds[1] tells us that "Pennsylvania work with tuberculosis is apparently based to a considerable extent upon the theory that owners realise the seriousness of the question, and that they will gladly co-operate if fairly treated, desiring to eradicate."

Kansas

Referring to the work in Kansas, Rogers[2] contends that "It is within the will power of 95 per cent. of the farmers of this country (U.S.A.) to immediately prove to themselves, and to the whole of the world, that they are not one of those owning dangerous tuberculous animals. Such a desirable attitude upon the part of 100 per cent. of the farmers who have not already done so would immediately locate all the dangerous tuberculous animals, and thus save the Government the expense of locating them in the interests of public health and of the farmers themselves; and with the part of the appropriations thus saved in this manner the unfortunate owners of tuberculous animals could be more fully reimbursed for condemnations and losses."

"When the extent of bovine tuberculosis was at first ascertained," says Moore,[3] "there was a tendency to radical State control and slaughter of infected animals, because of its supposed sanitary significance. The disease appeared to be one of such magnitude that the people looked to the State for both counsel and financial assistance in its eradication. The State efforts by legislation and official control, however, have not eliminated it as quickly as was generally anticipated; with a growing knowledge of tuberculosis and its parasitic nature, we are coming to realise more and more that it is not so much a matter of State as it is one for the individual to deal with. While many of our States have passed laws relative to the use of tuberculin in the official effort to control tuberculosis, a large number of cattle owners have privately attempted to eradicate it by the same means. In New York I have collected some data on this point. In 1907 I secured the results of the tests made (1904-06) with tuberculin on 683 herds, containing a total of 12,721 animals. Of these, only 262 herds, including 3,088 animals, were tested by the State, while 421 herds,

1. 6th I. C. on T., Vol. 4, pt. 2, p. 933.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 297.
3. 6th I. C. on T., Vol. 4, pt. 2, pp. 918-9.

with 9,633 animals, had been thus examined by privately employed veterinarians." Private enterprise

It is recognised that, considering the difficulties, no country has made better progress than Denmark, where the State encourages "the farmer to test on reasonable conditions."

In reference to the work in Wisconsin, Eastwood[1] tells us that "A large number of the farmers are enterprising, prosperous, making money rapidly, and correspondingly anxious to make more. This is the type of person who is capable of looking to the future, and of appreciating the financial advantages of eliminating tuberculosis, without being deterred by the temporary disadvantages arising from the length of time and difficulty involved in the attainment of this object. He anticipates a better return from his cattle, a better reputation and a higher price for his dairy products, and an increased value for land in districts known to be free from bovine tuberculosis. He would resent, and do his best to evade, any attempts at coercion, and his desire to safeguard the interests of human health may not be more than commensurate with the demand on the part of his customers for food products free from pathogenic germs ; but when he finds that rivals are trying to make more money by getting rid of bovine tuberculosis, his best energies are stimulated, and he is determined not to be left behind in the competition." Wisconsin enterprise

Regarding the conditions in our own country, Anderson[2] says, "While legislation and its interpretation by local authorities have been followed by a measured degree of success, a great deal of good has been achieved in raising the standard of the milk supply by private enterprise, and by such companies as the Copenhagen Dairy Company in Denmark, the Aylesbury Dairy Company in England,[3] and the Philadelphia Milk Commission of America. The aim of these companies has been to provide a naturally pure milk supply—a 'model' milk supply—rather than artificially purified milk by Pasteurisation or sterilisation, and hence the centre of their work is at the farm—the chief source of pollution." Private enterprise

Anderson[4] continues, ". . . . one must admit that there is a growing tendency, by many in every sphere of life, to placidly sit down waiting and hoping that some one else, or the State, will always do something, instead of determining one's own career by those ancient and traditional British qualities of self-help, self-reliance, and independence ; and farmers need only be reminded that, although the State is at British qualities of character

1. Dr. Eastwood's Rept., p. 5.
2. Dr. A. G. Anderson, D.Sc., M.A., D.P.H., Medical Officer of Health, Rochdale, Rept., p. 39.
3. One might fairly add Welford & Sons, Wensleydale Pure Milk Co., Scottish Pure Milk Co., Birmingham Dairy Co., and those dairymen working under the voluntary municipal schemes of Birmingham and Sunderland (see p. 305).
4. Dr. A. G. Anderson, D.Sc., M.A., D.P.H., Medical Officer of Health, Rochdale, Rept., p. 41.

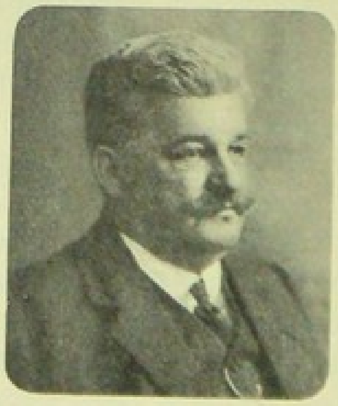
present contemplating some beneficial legislation for agriculture, it will avail them little without those qualities of mind and action."

Eastwood has observed the friendly co-operation of large American firms with their local health authorities, and although it does not always arise from such good motives as Anderson finds in England and Denmark—one may also include other parts of Europe, notably Germany and Vienna—the same is distinctly observable in this country, and is rapidly becoming an important determining factor already causing milk producers some anxiety.

Enlightened management

Eastwood[1] says, "There is also the policy of helping the strong and prosecuting the weak. Expressed in its most favourable light, this means that the big firms often desire to keep their milk up to a relatively high standard, and find it commercially advantageous to do so; whilst the small traders are perhaps less enlightened, and perhaps cannot afford the expense of the requisite improvements. Hence, it may reasonably happen that the working criterion of wholesome milk adopted by the local authority coincides with the criterion adopted by the wealthy firms, and an advantageous system of informal co-operation between the public officials and the business firms results; whilst the small dealer, who produces an inferior quality of milk and has no powerful interests to support him, can be successfully prosecuted with the utmost rigour of the law. This happy method of combining the interests of trade with those of hygiene is an important factor in the working of some of the American systems of milk control."

It would appear that the main points for the milk producers and stock breeders to bear in mind are—firstly, the disease is increasing among our herds; secondly, the State cannot afford to eradicate the disease.



W. H. WRAY, D.V.S., M.R.I.P.H.
United States Bureau of Animal Industry Chief Inspector for Great Britain.

As the pre-eminent stock breeders of the world, we cannot remain indifferent to the rejection of our prize animals when sent abroad.

Our prize animals rejected abroad

Coni[2] informs us that "During the year 1907 there were imported from Europe (into The Argentine) 1,799 bulls, of which 106 were sacrificed, having given reaction disclosing tuberculosis at the autopsy. In 1906, 2,753 bulls were imported, of which 227 were sacrificed, which is about 9 per cent. These reproducing animals have an individual value fluctuating between 1,000 and 2,000 national dollars."

It is to be presumed that probably the senders of the bulls referred to above believed them non-tuberculous. They were, therefore, partially selected animals.

Mohler[3] tells us that "....the inspector in Great Britain has

1. Dr. Eastwood's Rept., p. 45.
2. 6th I. C. on T., Vol. 4, pt. 1, p. 60.
3. 25th Annual Rept. B. A. I., p. 161.

rejected on account of tuberculosis as high as 33 per cent. of all the cattle tested by him in one year for shipment to the United States, and a large number of badly diseased herds have been located from which no importations are permitted."

The members of the International Commission on the Control of Bovine Tuberculosis appointed four committees from their number to deal respectively with—

(1) Education and legislation.
(2) Location of tuberculosis.
(3) Dissemination.
(4) Disposition of tuberculous animals.

The following is a reprint of the report of the first-named committee[1]:

" Bovine tuberculosis has become widely distributed throughout the United States and Canada, and it has been determined that efficient systems or methods for its eradication and prevention, either under the supervision of the State or nation or by the cattle owners themselves, are of necessity based on a knowledge of the nature of the disease and its means of dissemination.

" Experience has shown that the principles of eradication and prevention may be successfully applied by individual owners of infected cattle independent of State assistance. Such individual aid is essential in conjunction with State or national assistance in the prompt eradication of the disease from infected herds and the prevention of its entry to non-infected herds.

" Therefore it is the sense of this committee that every possible means should be employed for educating the cattle owners and the general public concerning the nature of tuberculosis; the care and precautions necessary to prevent its entrance into herds already free from the disease; and in methods for its eradication from herds where it now exists.

" Further, this committee approves of the following methods for instructing laymen, practising veterinarians, practitioners of human medicine, and health officers in the nature and control of bovine tuberculosis, namely:—

" 1. By the publication in agricultural and dairy papers of short, accurate, and carefully prepared articles on bovine tuberculosis.

" 2. By the publication of appropriate articles on bovine tuberculosis in veterinary, medical, and sanitary papers and journals.

" 3. By recommending to agricultural societies, granges, and directors of farmers' institutes and unions, and especially those interested in creameries and cheese factories, that lectures on bovine tuberculosis, its nature and control, be made a part of their programmes, and that, so far as practicable, demonstrations be held.

" 4. That those having in charge the arrangement of town, country,

1. Rept. Int. Com. on C. of B. T., p. 17.

and State fairs be requested to provide lectures on bovine tuberculosis, and, if practicable, to hold public demonstrations at their annual meetings.

"5. By placing a copy of the report of the Commission in the hands of the deans or directors of all veterinary and medical colleges and schools of sanitary science in the United States and Canada, with recommendations that special emphasis be placed in their courses of instruction on the nature of bovine tuberculosis and methods for its control.

"6. That a pamphlet dealing with the nature of bovine tuberculosis and methods for its control should be written in language intelligible to the layman. This pamphlet should have the approval of this Commission and the endorsement of the American Veterinary Medical Association. It should be published for free distribution.

"7. That departments of agriculture, State veterinarians, live stock sanitary boards, and others interested in the official control of bovine tuberculosis be requested to promote as much as possible the educational features of their work, with the object of obtaining more support and co-operation from cattle owners.

"The methods suggested for carrying out an educational propaganda are not to be considered to the exclusion of any and all other ways by which the public may become informed on the nature of bovine tuberculosis, its economic importance, and the necessity for an intelligent and united effort on the part of cattle owners and those having charge of the control of animal diseases to eradicate this great scourge.

"The committee is of opinion from the history of the legislation regarding bovine tuberculosis in those States and countries which have attempted to deal radically with the problem, as well as from the special information which has been furnished by this committee to its members, and the light thrown upon the subject in the discussions at its several meetings, that in order to avoid friction and failure, all important legislation with reference to tuberculosis must be prepared with due consideration for the condition of public sentiment and information on this subject.

"That tuberculosis control work should be developed in a progressive way.

"That tuberculin tests made at a distance for public recognition (for example, in other States or foreign countries) can only be done satisfactorily by official veterinarians.

"That the Delépine or Manchester plan of tuberculosis free areas gradually extended seems worthy of cautious trial.

"(Sgd.) M. H. REYNOLDS, *Chairman*,
W. D. HOARD,
J. G. RUTHERFORD."

Governor Hoard, of the above-named Commission,[1] in his report

1. Rept. Int. Com. on C. of B. T., p. 19.

stated : " I place a high value on the work this Commission may do, if performed wisely, in shaping the conviction and purpose of the people of Canada and the United States concerning the prevention and control of bovine tuberculosis.

" As yet, that conviction is but little more than an ill-defined dread of something not clearly understood by the great mass of farmers. Added to this dread is a hope stronger yet, that the evil is not as great as has been asserted ; that it is a scare that will soon pass over. As yet, in the minds of farmers and breeders generally, especially in those localities where demonstration work has not been done, there is a strong undercurrent of conviction that all this talk about the disease is an interested plea of the veterinarians, that the trouble does not amount to much if the doctors and editors would hold their tongues and pens.

" Just as long as this bank of fog exists, it will hamper all legislation and individual effort in getting rid of the difficulty. At the bottom of the matter is a widespread ignorance on the part of farmers as to the danger that threatens them ; it is difficult to arouse them out of their conservatism, for as yet, all they know about it is talk.

" The conservatism of intelligence is vastly different from that which exists because of a lack of knowledge. The first demands more light ; the latter dreads light."

EDUCATION OF THE FARMER.

Farmers' Reading Club

In this connection the Farmers' Reading Club organised by Peters in Nebraska is of interest. " This Reading Club," Peters[1] says, " is largely composed of farmers and stockmen throughout the State. Ninety per cent. of the members make stock raising their principal occupation. These men were interested in the Reading Club, and the only requirement made was that after a certain period they had to return question blanks, properly filled out, before they could secure new literature. Lack of funds prevented us from printing literature, but the Government and the Experiment Stations, having a large number of pamphlets that are well adapted for this work, were applied to, and sufficient copies secured. These were then gone over and questions prepared. These questions were shortly sent to the members of the club, who filled out and returned the reply blanks to the office. After the blanks had been returned, another pamphlet was sent to them. Not only have we used the members just for the Reading Club, but we have secured a number of them to do missionary work in their own locality and secure new members. Many of the members have urged stockmen and dairymen in their community to have their herds tested by our department or by the local veterinarian. In this way much good has been accomplished. We also feel that through this Reading Club we are securing a large number of people who will be willing to give accurate information to our

1. 6th I. C. on T., Vol. 4, pt. 2, p. 760.

various stock associations and to the members of our legislature if it becomes necessary to pass a suitable law for the eradication of tuberculosis from the State."

Causes of Wisconsin progress

With reference to the progress in Wisconsin, Dr. Eastwood[1] quotes facts showing that "....the efforts to eradicate bovine tuberculosis are making some progress. To what causes," asks Eastwood, "is this encouraging position attributable? As Mr. Hoffmann's[2] share of the work brings him into direct and intimate contact with the farmers, his experience has the value of first-hand information. He attributes the success of their work to the following causes:

"(1) First and foremost, the *post-mortem* demonstrations to farmers. These are arranged at county fairs in various parts of the State, in the Agricultural College, and wherever opportunity arises. They are prefaced by a popular lecture explaining the financial loss arising from tuberculous cattle, the insidious nature of the disease, and the economic advantages of detecting and eradicating it at an early stage. The farmers are invited to inspect a batch of animals which have reacted to the tuberculin test, and special attention is called to those beasts which from their external appearance would be regarded as perfectly healthy. The animals are then slaughtered, and the extent and nature of the disease is demonstrated to the farmers. In this way the practical value of the tuberculin test is proved far more convincingly than by verbal arguments and theories.

"(2) The publication, at frequent intervals, of practical advice to farmers in the Bulletins of the Agricultural Experiment Station, which is in co-operation with the Wisconsin Live Stock Sanitary Board.

"(3) The free distribution of tuberculin, on condition that the farmer obtaining it furnishes a complete record of the test.

"(4) All students at the Agricultural College are taught how to employ the test. Special short courses are arranged for farmers at convenient seasons of the year. The number of students receiving this instruction now amounts to 1,000 per annum.

"(5) The farmer is offered the choice of three methods for the disposal of infected animals. [These methods are defined.]

"(6) The farmers who have adopted the test approve of it and recommend it to their friends.

"(7) Farmers are advised not to replenish their herd except from tested animals."

(8) Under this number reference is made to the cities demanding tuberculin test for cows supplying milk (see p. 283).

Pennsylvania progress

Commenting on the fact that the authorities in Pennsylvania have never been able, with the funds at their disposal, to comply with the increasing number of requests of the farmers for free tuberculin

1. Dr. Eastwood's Rept., p. 2.
2. Hoffmann is devoting special attention to this subject under the direction of Dr. H. L. Russell, Agri. Exp. Sta., University of Wisconsin.

testing under the voluntary system ruling there, Klein[1] attributes this demand to the "....increasing knowledge of herd owners and the general public regarding tuberculosis in cattle; and it is believed," Klein continues, "that no one thing did more to convince cattle owners of the economic reasons for repressing the disease in cattle than the policy of the State Live Stock Sanitary Board in arranging for them to witness *post-mortem* examinations of reacting cattle. When reacting cattle are to be destroyed on a farm, the farmers of the vicinity are afforded an opportunity to witness the *post-mortem* examinations, unless, as happens in some rare cases, the owner desires to avoid publicity; and it has been repeatedly observed that whenever cattle are disposed of under these conditions, a number of applications for herd inspections are received from the locality."

Governor Hoard,[2] of Wisconsin, in his report to the American Veterinary Medical Association, strongly confirms the opinion expressed above. "One animal slaughtered before a body of farmers," he says, "and the diseased parts exposed to their plain view, is worth more to foster conviction and inspire effort than anything else that can be done....we must remember," he continues, "that with the majority of men, a large majority, 'seeing is believing.' We have gone as far as this in legislation, that after December 1st, 1910, all animals sold for breeding or milking purposes must first be tuberculin tested.[3] This, I believe, is a step farther in advance than has been taken by any other State. It shows well the tone and temper of our farmers and the work which has been done to acquaint them with a true understanding of the situation. It is needless for me to say that if they are for the law, or any law, it goes; if they are against it, it is at best a dead letter."

Regarding the funds necessary to bear the expense of demonstration, Hoard believes "The farmers everywhere would willingly be taxed for its support. Municipalities could well afford to have such expense for the sake of the education it would afford to consumers of meat and dairy products."

Pope[4] says the success of the crusade of suppression of tuberculosis must ultimately depend upon the farmers' co-operation and support.

Suggestion for local authorities

"The possession by the local authorities," says Eastwood,[5] "of a clean herd or herds, intended for the supply of public institutions, would be a valuable object lesson. There is nothing impossible about the task of keeping out infection; it is merely a question of exercising sufficient care, and it ought not to be impossible to appoint competent men for the work. The most effective way of teaching the farmer the way to success is to show him, in his own district, that success actually is being achieved.

1. 6th I. C. on T., Vol. 4, pt. 2, pp. 548-9.
2. Rept. Int. Com. on C. of B. T., p. 19.
3. Governor Hoard, Editor of the world-famous American journal *Hoard's Dairyman*, informs us that this law has since been repealed.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 571.
5. Dr. Eastwood's Rept., p. 26.

" Local authorities, by establishing and maintaining clean herds for the supply of public institutions, would provide a valuable means of educating the farmer."

Ignorance of cattle owners

M'Fadyean[1] stated in 1901, "The greatest obstacle to successful action against tuberculosis, whether in man or animals, is the ignorance of the laity regarding the cause of the disease. The immense majority of cattle owners are not yet convinced that contagion is the only cause of tuberculosis, and very few of them have yet made the slightest effort to check the spread of the disease. As a rule, cows and other cattle visibly ill from tuberculosis are still left alive and in close association with their fellows, although the lowest grade of common-sense and prudence would suggest that such animals ought to be promptly killed, or, at least, isolated. It is not want of commonsense, nor is it mainly lack of means that is responsible for this inaction ; it is simply a want of conviction on the part of cattle owners that tuberculous animals are dangerous to their companions." Mr. Adeane[2] believes there is in this country an immense amount of ignorance on the question of bovine tuberculosis. He did not himself realise until recently that tuberculosis is not hereditary, and he is convinced that every farmer in the country did not know tuberculosis could be wiped out of his herd by means of isolation.

Mr. Mansell[3] believed that the majority of the farmers could and would isolate if the landlords would provide the facilities.

The ordinary man does not know that tuberculosis is not hereditary but only contagious, hence the reason for the demonstration which the Royal Agricultural Society are now making, by the kindness of Lord Rothschild, than whom, probably, no living expert has done more for the practical advancement of cattle breeding.

IS THE FARMER WILLING ?

The farmers antipathy to the tuberculin test is largely due, says the Editor of the Breeders' Gazette (U.S.A.),[4] to " The kill-all-without-compensation method early advocated by some extreme scientists and veterinarians."

In order to be successful in eradicating tuberculosis, Deering[5] contends the cattle commissioners must have the co-operation of the owners of the cattle. In the State of Maine they are succeeding well in this direction. From Deering's account it is evident confidence has been established between farmer and authorities, and procedure is working well and smoothly.

In Pennsylvania, Klein[6] tells us, about as many cases of advanced tuberculosis of the udder are reported to the Board by the owners as by veterinarians.

1. Trans. B. C. on T., p. 85.
2. Mark Lane Express, May 9th, 1910, p. 555.
3. Mark Lane Express, May 9th, 1910, p. 555.
4. Private letter to Prof. Jesse E. Pope. (See 6th I. C. on T., Vol. 4, pt. 2, p. 573.)
5. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
6. 6th I. C. on T., Vol. 4, pt. 2, p. 551.

Peters,[1] of Nebraska, believes that if they "....make common-sense requirements the farmers will gradually co-operate....and meet every reasonable requirement."

Peters[2] has been watching the progress that is being made in States other than his own, and says, "....the more I have studied the question the more I have become convinced that when the stock-man is thoroughly familiarised with the issue, and given plenty of time to think over the question, he is a very good man to work with, and would favour reasonable legislation."

This view would seem to describe the feeling in our own country, if we may judge from the manner in which the agricultural authorities received the Rt.-Hon. John Burns' first Milk Bill. The elements of reform embodied in the Bill were welcomed. All agreed that it was time to take further steps against tuberculosis. All were willing to help, but none were willing to be penalised for the existence of the disease; hence the fate of the Bill. Mr. Burns proposed that the funds for compensation should be provided from local rates, that is, practically, the owners of the tuberculous cattle were to pay for the process of suppression. As a measure of legislative acumen this was undoubtedly admirable, and certainly only a nationalisation of the powers already acquired by a few of the largest cities; but the cattle owners considered that the main benefits from the procedure were to be enjoyed by the consumers of the milk, and, therefore, the consumers should assist in paying the cost, that is, the funds should be derived from the Imperial exchequer.

Wealthy corporations safeguarding the health of large populations are very different organisations from rural councils with a limited number of inhabitants and a large number of tuberculous cows under their jurisdiction.

Bang[3] appears to have spent a good deal of time in convincing farmers that tuberculosis is not a constitutional disease which is caused partly by hereditary predisposition and partly by anything that weakens the organism.

"This idea," he says, "was the prevailing one not so many years ago with regard to cattle as well, and it is undoubtedly still pretty widely spread among farmers.

"In former days, farmers were especially afraid of the heredity of tuberculosis. This was not altogether unreasonable, as at that time only those cows were considered tuberculous in which the disease showed clinical symptoms, and among such animals there would be danger that a few might bear tuberculous calves. But when the tuberculin tests in 1891 and 1892 showed that, in herds in which for years cases of the disease had been found, a majority of the cows (often 80 to 100 per cent.) reacted, it was not clearly understood that these great numbers meant simply that the majority of the cows were

1. 6th I. C. on T., Vol. 4, pt. 2, p. 611.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 760.
3. 6th I. C. on T., Special Vol., p. 207 *et seq.*

infected, but by no means signified that the reacting cows were sentenced to death, and after a longer or shorter period would succumb to tuberculosis. This great number of reacting cows made the farmer despair. He had, perhaps, in the course of many years, raised a fine and productive herd, and now everything seemed lost. The cows would perish, and how could he maintain the stock when he was afraid to raise calves from tuberculous animals? He often regarded himself as ruined.

Infection alone spreads bovine tuberculosis

"It is, therefore, of some interest to call attention to the fact that, so far as cattle are concerned, it can be quite clearly proved that the disease is introduced and spread by infection, and by infection alone. This can be proved for entire countries and parts of countries, as well as for herds in a country. Twenty years ago I called attention to the circumstance that Denmark a hundred years ago seems to have been entirely free from the disease, and that it was introduced by cattle from other countries where the disease had its seat from early times, as Switzerland, North Germany, and England. In Sweden, Norway, and Finland exactly the same conditions are found. The cattle in these countries were healthy until tuberculosis was introduced with cattle from England, Holland, or Denmark. Furthermore, a thorough investigation of the dissemination of bovine tuberculosis in a country where it is now common, as, for instance, Denmark, shows that it is by no means found in all herds. The numerous tuberculin tests of entire herds made in Denmark have shown that nearly a quarter of the herds tested were free from the disease, and in Norway, where the disease appears far less frequently, this fact is established for more than four-fifths of the herds, which are tested there also on a large scale.

Rear your own calves

"These investigations show also that the entirely healthy herds are those that multiply by their own breeding, while the disease is found where the farmers trade cattle and import animals descended from infected herds. In other words, tuberculosis acts just like any other contagious disease—the disease appears only when the contagion is imported.

"As the importation of foreign animals often takes place in order to improve the cattle—for instance, to increase the yield of milk—it might be assumed that this somewhat forced development of the products of the animals was the real cause of tuberculosis, an idea quite common in former days. In order to throw light on this question, I tested with tuberculin, sixteen years ago, two of the most celebrated of milch cows in Denmark, cows that had taken the highest prizes. They consisted of animals of marked milking type, lean and fine, with little meat, but producing much milk, and in breeding had been used to a high degree in both herds. According to the old conception, these animals would be considered specially disposed to tuberculosis, but they proved to be perfectly healthy, without doubt because for many years no foreign animal had been introduced into these herds. In the herds in which tuberculosis is found it is often easy to point out the animal that has introduced the infection, and to show that the disease has spread first of all to those animals that have come most in contact with the infected one."

Bang also informs us that there are many, even among physicians, who cannot rid themselves of the idea that the tubercle bacillus is ubiquitous.[1]

"The conditions that I showed," says Bang, "with regard to bovine tuberculosis prove absolutely that tubercle bacilli are not found everywhere. If they were, it would be impossible to have perfectly healthy herds in a village in which many other herds are infected."

Tubercle bacillus not ubiquitous

We have already referred to Schroeder's[2] words that "The indispensable cause of tuberculosis is the multiplication of tubercle bacilli in the animal body. Bacilli do not grow and multiply in animal bodies until they have been introduced into them from without, and tubercle bacilli grow and multiply nowhere else in nature."

Delépine[3] found that farmers "....are nearly all averse to the use of tuberculin." Probably the "....fatalistic inertia" that Newsholme[4] refers to, in the companions of sufferers from the human disease, is still an important obstacle to the average British farmer.

Fatalistic inertia

EDUCATION OF THE PUBLIC.

Speaking at the Sixth Congress on Tuberculosis, Dr. Meyer,[5] of Louisiana, said: "When this great triennial Congress shall have adjourned, it will be found that its most important pronouncement will be 'educate the masses.' However backward Louisiana may be in exhibits and public sanitation, she is at least a pioneer in insistence on this necessity. The whole scheme of the Louisiana system of hygienic education is based on two principles:

"First, the necessity of instructing the masses in the cause and prevention of all contagious and infectious diseases, and especially those common to man and domestic animals, like tuberculosis.

"Second, the duty of the State to furnish this instruction; this duty is apparent not only from a humanitarian standpoint, not only because under free Governments men have and claim an inalienable right to life, liberty, and the pursuit of happiness, this being inseparable from the *mens sana in corpore sano*,[6] but from an economic point of view, because it is cheaper to prevent than to cure, or take charge of the human physical derelicts as they float on the waters of life, a menace to every other object they meet."

Better prices needed

Peters[7] says that "....if we are to have the very best dairy products that can be produced according to modern requirements,

1. Thus Willson and Rosenberger refer to the "....armament, the subtlety, and the ubiquity of tuberculosis" (6th I. C. on T., Vol. 1, pt. 2, p. 611).
2. B. A. I., Bull. 56, p. 529.
3. 38th Annual Rept. L. G. B., Suppl., p. 410.
4. The Prevention of Tuberculosis, p. 339.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 784.
6. A sound mind in a sound body.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 611.

the farmer must receive better pay for his articles. We need to go into the cities and towns and teach the city people the difference between good and bad milk."

In tracing the conditions necessary for success in eradicating tuberculosis, Deering[1] requires, in the first place, "a good, healthy public sentiment." Reynolds[2] says "We must take up the most serious and urgent problem in order, and the work must continue to be something of an evolution." In discussing the means of averting the danger from bovine tuberculosis, M'Fadyean[3] says, "The first thing necessary in this connection is education of the people regarding the nature of the disease. It is necessary because in this country, where Parliament never moves except by the force of public opinion, the legislative action required will not be taken unless the people are satisfied of its wisdom, and also because even the most drastic sanitary measures enforced by the law are likely to fail if they are not supplemented by the intelligent co-operation of the people. The National Association for the Prevention of Consumption and the Royal Agricultural Society have been endeavouring to disseminate sound views regarding the cause of bovine tuberculosis among farmers and others, but much remains to be done in this direction. But it is not reasonable to ask that things should be left as they are until the education of the farmer in the matter of tuberculosis has been finished. If there are any practicable and reasonable measures by which, figuratively speaking, the flow of tubercle bacilli from tuberculous cows to healthy human beings can be stopped or impeded, they ought to be immediately enforced."

Dr. Henry Barton Jacobs,[4] of Baltimore, recommends that as "The battle against tuberculosis is not to be won in any single generation....why not concentrate upon those who are to become the next generation?" He therefore recommends teaching the material facts concerning tuberculosis in the schools.

Start in the schools

Mohler[5] also advocates this view, and points out that the consumer must expect to pay more for better milk. Eastwood, and also Newsholme, have advocated this latter point (see Section III.).

Koch-Stiftung

In 1908 the activity of the President of the International Anti-tuberculosis Alliance enlisted the co-operation of all grades of society in Berlin, and created a foundation, as Koch[6] informed us, in commemoration of the twenty-fifth anniversary of the discovery of the tubercle bacillus, and this foundation was named the Koch-Stiftung.

Mr. Carnegie contributed about 250,000 dollars, but about two million dollars were requisite for the Institute to properly undertake

1. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
3. Trans. B. C. on T., p. 85.
4. 6th I. C. on T., Vol. 3, p. 621.
5. B. A. I., Circular 153, p. 28.
6. 6th I. C. on T., Vol. 3, p. 809.

its great work. Koch said, "Such an institution should also be a central depository and clearing-house of all the scientific work of the world in this subject of tuberculosis."

CAN THE FARMER AFFORD THE NECESSARY PRECAUTIONS ?

Expense

"The questions of sanitation and disinfection," says Pope,[1] "have occasioned much irritation. Unless a great deal of commonsense is used by the authorities, the changes required in buildings and premises are so expensive that farmers revolt or go out of business. What State and farmer need fully to grasp is that the presence of infected cattle is frightfully and persistently expensive, and that the necessary precautions are so costly and troublesome as to be hardly possible, while even when they are consistently taken, the results obtained are often most discouraging."

No demonstration is necessary to prove that the ordinary farmer, who is usually a tenant, has neither the means nor other resources to carry out the necessary hygienic improvements and isolation of reacting cattle. The expense of testing is not the difficulty, but to pursue the course having once embarked on it is quite another matter. If one cannot pursue it to a finish it is risky to start at all. At least, so it appears to the average farmer.

Pope[2] says, "....if you are a breeder of cattle and you think that 90 per cent. of them will react to the test, you are not going to submit to it. You would be ruined, and you know it."

No Incentive

On the other hand, [3]"What incentive is offered to the owner of a dairy herd that is free from disease to keep it so, when he must meet in competition the products of a diseased herd ?"

Notwithstanding these apparently sound arguments, which would seem to admit of general application, we have in our own country to deal with the very significant fact that at the moment, guaranteed non-tuberculous milk is being sold without increase of price. Although this movement shows distinct signs of development, it will become increasingly difficult, and it is doubtful if it could be realised generally under present conditions.

It has thus resulted that the

PRINCIPLE OF INDEMNITY IS FIRMLY ESTABLISHED.

Reynolds[4] regards it as "A necessary preliminary procedure." Moore[5] admits that, although the eradication of tuberculosis is primarily a personal problem for the cattle owner, "The State and nation have their responsibilities concerning it," and considers the

1. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 583.
3. Dyson, 6th I. C. on T., Vol. 4, pt. 2, p. 515.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 918.

solution of the question "....is to be found in the methods adopted and followed by the individual owner, protected by proper legislation, and given as much other assistance by the State as the legislature may see fit to confer."

State should assist

Melvin[1] states that "....as the eradication of tuberculosis is largely a public health measure, it is only reasonable that the State should compensate, at least in part, the persons whose cattle are slaughtered."

Pope[2] considers "that State and farmer may effectually co-operate in stamping out tuberculosis. The farmer feels that the direct financial loss should be met by society as a whole, which, as consumer, would be more than repaid for the expenditure, and that the indirect costs which he must bear constitute his own fair contribution."

The principle of State indemnity was admitted in the Rt.-Hon. John Burns' Milk Bill—only in the case of active disseminators of disease, it is true, but it is natural that public Ministers cannot see their way to open the nation's coffers unless some very tangible and lasting benefit is to be secured; in short, the transaction must be commercially sound, and in this case the destruction of cows suffering from udder tuberculosis is universally recognised as a crying necessity.

TO WHAT PURPOSE SHOULD STATE FUNDS BE DEVOTED?

"The amount of money," says Eastwood,[3] "which even the richest community can afford to spend in the interests of agriculture is limited, and usually appears insufficient to meet all the reasonable demands which agriculture may make upon it. It is, therefore, necessary to consider how the sum available can be spent most usefully. If the State compensates for tuberculous animals which are worthless on the open market, will the money so spent be productive, in the economic sense of the term, *i.e.* will it increase the food-producing value of the herds in the community? Emphatically, no. It is impossible to study American experience of compensation without forming a definite opinion on that point. When a herd contains animals broken down with tuberculosis, it practically always contains also other animals in a less advanced, but progressive, stage of the disease. The mere elimination of the former animals does not produce a clean herd; the other infected animals gradually develop the condition of those already slaughtered, and continue, by their fæcal and other discharges, to pass on the infection to new arrivals. So the process goes on indefinitely, and the payment of compensation for broken-down beasts is a positive encouragement for its continuation. Public money expended for this purpose is worse than wasted; by rewarding

1. 6th I. C. on T., Vol. 4, pt. 2, p. 511.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 578.
3. Dr. Eastwood's Rept., p. 21.

the farmer who is unwilling or unable to adopt effective measures of control, it actually aids in the continued propagation of the disease, and so contributes to a further diminution of the food-producing value of the live stock in the community. No community which is seriously desirous of fostering commercial interests can be justified in adopting the suicidal policy.

[1]" In considering what further expenditure out of available public funds may be devoted to the agricultural interest, it is again useful to learn a lesson from American experience. In the campaign against bovine tuberculosis the strength of the enemy is so overwhelming that money expended on a frontal attack is generally money wasted." Eastwood[2] devotes six of his conclusions on this matter as follow:

" (2) *It is imperative, in the interest of agriculture, that dairy cows with advanced or generalised tuberculosis, or with tuberculosis of the udder, should be destroyed.*

" (3) *The public must be prepared to meet all the costs of adequately inspecting the condition of dairy cattle.*

" (4) *It is essential, in the interests of agriculture, that compensation should not be paid out of the public funds for slaughtered cattle showing advanced or generalised tuberculosis or tuberculosis of the udder.*

" (5) *The testing of entire herds with tuberculin should be encouraged, and for this purpose the assistance of public money is requisite and desirable.*

" (6) *Public money spent on re-testing, with a view to establishing thoroughly the soundness of herds giving on the first test either no reactions or only a small percentage of reactions, would be money well spent.*

" (7) *Reacting animals possessing a market value might, under special circumstances, be taken over by the community at a price exceeding their market value; but, with this limited exception, compensation out of the public funds does not appear to be justifiable.*"

Concerning the losses which eradication would involve to the farmer, it is stated, says Delépine,[3] that farmers cannot reasonably be expected to adopt measures which would be contrary to their own interests. " If the matter could be considered in the light of a commercial transaction affecting only one generation of speculators having no responsibility towards their country or humanity, the above argument might be considered sound. It is, however, the duty of the State to see that the present generation does not sacrifice for its own benefit the patrimony of future generations, thereby doing great harm to the country. It is also the duty of the State to see that

1. Dr. Eastwood's Rept., p. 23.
2. Dr. Eastwood's Rept., p. 78.
3. The Lancet, Aug. 24th, 1901.

any condition of things which tends to perpetuate the existence of a disease which is so detrimental to man as well as to the lower animals is checked as speedily as possible."

MR. JOHN FREW'S SCHEME.

Indemnity in case of sickness

In a paper read at Dunfermline, in 1908, Mr. John Frew,[1] County Inspector, asks: "....is it too much to hope for in this democratic age that the Government who can vote seven millions for old-age pensions to help to ameliorate and prolong the lives of old men and women above seventy years of age, will make proper provision for paying compensation to all dairymen who, in the interests of the public, are prohibited from selling their milk because of a diseased cow, or owing to illness in their families?

"This, I am convinced, would do more to eradicate tuberculosis and bring to light any illness at the dairy than any measure yet proposed. There would then be no inducement for the dairymen to keep a few piners in a secluded outhouse, nor to carry on their business with a case of scarlet or typhoid fever hidden away; for, after all, even dairymen are only human, and to most of them the loss of a few cows, or the stoppage of their trade, even temporarily, means a great deal."

At the April quarterly meeting of the Massachusetts Association of Boards of Health, 1907,[2] a prominent dairyman of the district, Mr. Whiting, made the following statement:—

"I would like to mention one safeguard we have recently put on our milk supply. In our contract with farmers we state that in the event of any infectious disease in a farmer's family, or on his premises, we will pay for the milk produced which shall be poured upon the ground each day while in quarantine; so there will be no temptation for a milk producer to ship milk for one or two days after suspicion of some infectious disease. We look upon this provision as an extra safeguard."

It would thus appear that Mr. Frew's proposition was actually in operation on a commercial scale at the time he read his paper, a striking proof of practicability. It is also in operation at present in the case of a prominent and high-class dairy company in the north of England, and in the largest dairy firm in Britain.

Hygienic cowsheds

"What we want," says Frew,[3] "is large, airy, well-lit byres, as closely assimilated to open-air conditions as it is possible for them to be. As to who is to do this, we may say that we cannot expect the dairyman or the landlord to spend all that money without adequate return. Might not the Government step into the breach by lending money to build new and open byres, and let the public who are to

1. The Scottish Farmer, Jan. 8th, 1910, p. 29.
2. Amer. Jour. of Pub. Hyg., Vol. 17, No. 2, May, 1907, p. 195.
3. The Scottish Farmer, Jan. 8th, 1910, p. 29.

benefit pay their proportion of it by paying an increased price for the article produced."

Mr. C. W. Walker-Tisdale[1] has it that "With unsuitable byres, cramped for space, ill-lighted, and badly ventilated, and with the food store in the same building where is stored dusty hay and strong-smelling roots and cakes, the production of perfect milk, as it might be called, is no easy matter.

"And yet this is what innumerable tenant dairy farmers have to put up with. They pay fair rents, but the landlord either has not the money or will not expend it on improvements, and the tenant cannot undertake, even if he had the means, to improve the landlord's property.

"Thus, whilst dairy farmers are pressed to reform, there is generally no incentive offered either in the form of an increased price for the milk or assistance from the owner of the property."

It is interesting to note that Mr. John Frew's suggestion is gaining adherents. Thus Dr. Wm. Watson,[2] of Glasgow, reasoning from the success in combating human tuberculosis by effecting sanitary improvements in the dwellings of the people, at public expense, inquires: "Could public money not be used for purposes which seem as laudable to rid our herds of infected animals, or to encourage and assist by grant or loan in making sanitary the accommodation on our smaller holdings? The beneficial influences of our sanatoria have proved not only their value in the treatment of consumption, but what lies at the root of conditions fostering it, so that we might well adopt similar methods in the prevention of it."

We also find that J. W. Brittlebank[3] supports Mr. Frew's proposal.

Mr. John Frew's scheme seems the most feasible way out of this difficulty, especially if Edwards' recommendations are as sound as they appear. Professor Pope[4] tells us that "Hon. W. C. Edwards, of Rockland, Ontario, owing to his public spirit in dealing with tuberculosis in his own herd, has been widely quoted as to the efficiency of the Bang method. The following extracts from a personal letter, written in September, 1908, ought to be of interest: 'I most certainly think that the Bang system is a most excellent one for any one to practise. I may say, however, that I do not think that many farmers, or even breeders, will go to the expense and trouble involved in the practice. Personally, I may say that the riddance of tuberculosis through the Bang system is very effective; but is very expensive to practise as we practise it here. If I had to do it over again, my plan would be to found a distinctly new herd on a separate farm, or remove some distance from the buildings of our present farm, in an entirely

Found a new herd

1. Agri. Gazette, May 3rd, 1909, p. 421.
2. The Scottish Farmer, Feb. 18th, 1911, p. 138.
3. The Veterinary Record, June 6th, 1908, p. 877.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 576.

new set of buildings or buildings thoroughly disinfected. There keep a certain number of thoroughly healthy nurse cows, and from each cow of our pure-bred herd that we wish to make the foundation of our new herd, take the heifer calves as immediately dropped and remove to our new premises, and through this process in a few years have an entirely new and fresh herd.'"[1]

Mr. Edwards insists that with the most careful testing you can never be sure that you have weeded out all affected animals, since "some of your finest and most robust animals are those which have the disease in the most severe form, which clinical examination cannot discover. While I am a believer in the test (tuberculin), I am not a believer that it is efficacious in every instance, and herein lies the danger of it. It, however, can be made useful, and is useful in many ways. But in applying it year after year, or even every six months, to ascertain the real condition of the herd, the most serious mistakes can be made and are made. This, I frankly tell you, has been our greatest difficulty, and has resulted in enormous loss to us. So much so, that I am going to practise exactly what I have stated above, viz. I am going to have an entirely new, separate, and distinct herd."

Referring to the United States work, Eastwood[2] quotes figures of losses which, ". . . . whilst not justifying contribution from the public funds of a single cent towards schemes which fail to satisfy the elementary principles of economics, prove that on schemes where the capital expenditure is likely to bring adequate returns, calculable on a financial basis, public money ought to be freely spent and could be well invested.

"*The difficulty at present seems to lie not so much in the lack of public support of a financial nature as in the lack of evidence that the agricultural interest is prepared to turn to good advantage such effective public support as might be offered.*"

Pope's scheme

We fear that Pope[3] is beyond the range of practical politics, in this country at any rate, in suggesting that "As soon as an animal is known to be tubercular it should become the property of the State, and if destroyed should at once be paid for at its full market value unless it shows physical signs of the disease." [4]"It would, of course, be impracticable," he admits, "for all infected cattle to be taken in charge at once; a given region would have to be districted, and careful provision be made so that districts cleaned of the disease would not become reinfected."

Eastwood's scheme

Nevertheless, Eastwood[5] contemplates a modified scheme on these lines. He says, "In fighting a disease which is constantly spreading,

1. When dealing with a herd in which a large number of valuable animals react to the test, Professor Sir John M'Fadyean agrees that this is the best plan (Jour. R. A. S. E., 1910, p. 41).
2. Dr. Eastwood's Rept., p. 27.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 579.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
5. Dr. Eastwood's Rept., p. 24.

it is very important, especially at the start, not merely to secure thoroughly healthy foci and to increase their number, but also to increase the number of these areas quickly, so that the healthy zones may expand or multiply at a more rapid rate than the extension of the disease. As the saving of time means the saving of money, there is a *primâ facie* case for asking the State if it will aid such an enterprise. To suggest a possible instance, in a district where the value of the tuberculin test is appreciated, and where it is possible to replenish stock by the purchase of clean animals, there may be found perhaps a dozen herds, in each of which the reacting cows are few in number and possess a fairly good market value. If the owners of these are merely advised to adopt the Bang system, it will take several years before any of the twelve farms are completely cleaned up, and probably some of them never will be. But if the infection could be removed from all these farms at once, it would be a substantial benefit to the community at large. To secure this result promptly might be worth the expenditure of public money. On this account, the local authority might be justified, in certain carefully selected cases, in offering to buy up all of the reacting animals on generous terms, viz. at prices based on the assumption that the animals were all worth what they would be if treated on the Bang system with the maximum possible care and skill. As this would be above the market price, a private dealer could not afford to offer such generous terms; therefore, there would be a strong inducement for the farmers to accept these terms and to start at once with the advantage of clean herds. The local authority would collect all the reacting cows in an establishment under its own control, with an official guarantee of the adequacy of the Pasteurisation; the business would be conducted as it actually is conducted under the ordinary Bang methods, whether for the supply of public institutions or for the general market. In so far as the farmer would receive more than the market price for his tuberculous animals, he would receive 'compensation.' This appears to me to be the maximum, at least in the old country, which can under any circumstances be advantageously offered by way of compensation to the individual out of the public funds."

Remove reactors from good herds

"An interesting feature of the Pennsylvania work," says Reynolds,[1] "is that when cattle are killed for beef and incidentally found tuberculous to an extent which condemns the carcass for food purposes, the carcass may then be appraised and paid for by the State at a price not exceeding $25 for the entire carcass."

CONDITIONS THE STATE SHOULD DEMAND FOR ASSISTANCE.

In Pennsylvania, [2]"If an owner wishes to have cattle tested, he makes application to the Sanitary Board. In order to secure this assistance, he must agree to aid in the examination; to quarantine

1. 6th I. C. on T., Vol. 4, pt. 2, p. 933.
2. Reynolds, 6th I. C. on T., Vol. 4, pt. 2, p. 933.

reacting animals promptly; to disinfect stables; and to improve the stable sanitation if directed to do so." The owner "....must agree to re-test at his own expense within eight months, provided one-fourth of the original herd be found to be tuberculous. He also agrees that he will not add any untested cattle to his herd thereafter."

Owner must maintain improvement made

Eastwood[1] sums the matter up as follows: "When a farmer is to have his herd tested free of charge, and to receive compensation for reacting animals, he must sign an agreement, the gist of which is that the State will clean up the man's herd, provided that the man will keep it clean. The State forthwith performs its part of the bargain, but is there any adequate guarantee that the farmer will perform his? I was not able to obtain any statistics as to the number of herds, inspected free of charge by the State, which have remained clean. It seems difficult to understand how this 'agreement' can be regarded as a valid contract, with a legal sanction behind it compelling the farmer to fulfil his part of the bargain."

[2]"In many parts of America the State offers to come to the aid of the farmer and to do the testing of all his cattle free of charge, provided that the farmer will enter into an 'agreement' to take certain steps towards the eradication of tuberculosis. The aspect of this system which seems deserving of admiration and imitation is the offer of the State to test the farmer's entire stock. The feature which appears less commendable is the 'agreement,' since there is not adequate provision for compelling the farmer to fulfil all he contracts to do. Many of the clauses in the agreement are often a dead letter, not worth the paper they are printed on; the offer of such a contract is bad business, and therefore bad policy. Substitute for the 'agreement' payment in cash, and the method would be admirable. On receipt of a minimum fee from the farmer, say two guineas, the public authority might undertake to send a skilled veterinarian, well acquainted with the agricultural conditions of the district, who should test all the farmer's cattle, inspect his premises, offer suggestions as to the best methods of dealing with reacting animals, and, if desired to do so, discuss and advise upon the farmer's business affairs in connection with his cattle. And there the transaction should end. No interference, coercion, or compulsory slaughter; no compensation; and no promises for the future. In some cases, farmers living near together might combine and so reduce the expense. The fees would not cover the cost of the work, but they would be the best guarantee available that the farmers were able and earnest in their desire to improve the general condition of their stock; and this guarantee might be taken as sufficient to justify the requisite expenditure of public money on the work of testing. It would be desirable to have all the tuberculin prepared in a central laboratory supported by imperial funds, and, in order to facilitate the requisite central supervision

"Fee" preferable to "agreement"

1. Dr. Eastwood's Rept., p. 11.
2. Dr. Eastwood's Rept., p. 22.

and control, it would be advantageous to require that reports of all the tests made, and of their results, should be sent to the central laboratory. In Washington, for example, the Bureau of Animal Industry furnishes tuberculin to Federal, State, County, and City officials on condition that the testing shall be done by skilled persons under official supervision, and that the results of the work shall be reported to the Bureau. When visiting their Laboratory I was informed that for the year ending June 30th, 1908, 215,000 doses were sent out, and that their cost, including all working expenses, bottling and packing, amounted to about two cents per dose."

". . . . as soon as the disease is well in hand," says Pope, [1] "it should clearly be set forth that the individual must be strictly responsible for keeping his herd free from disease, and must himself bear the expense."

"Stables must be refilled," says Reynolds,[2] "with tested cattle only, or the owner should forfeit his right to future indemnity.

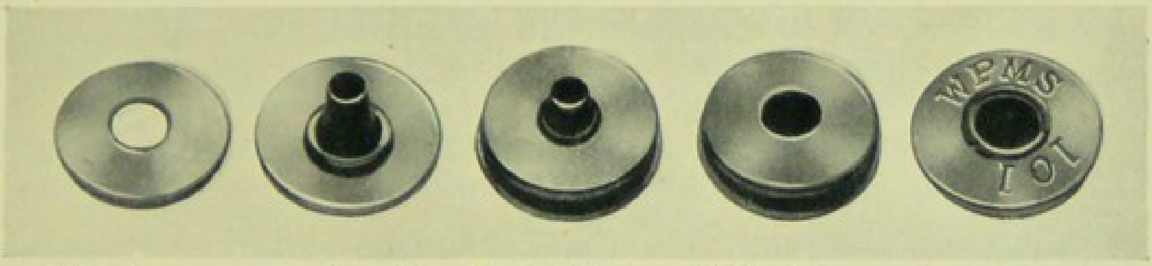


PHOTO.] FIG. 10.—Eyelet Buttons (*full size*). [J. MURGATROYD.

There must be used some reliable system of marking that will obviate the probability of fraud."

Ear tagging

For this purpose Rogers[3] recommends ear tagging. Noack[4] says ear tags are easily torn from the ears of animals in transit, and recommends burning on the shoulder, but the most recent American method is that of punching the letter "T" out of the ear.

After examining various forms of American ear tags, we are pleasurably surprised to find that the contrivance made for the purpose in England seems decidedly preferable. Instead of a loose ear-ring, as used in America, the ear marker as employed by Mr. Malcolm, Chief Veterinary Officer of Birmingham, and by the dairy companies controlling tuberculin-tested cows, consists of a double button punched through the ear and clinched in one operation with a special closing tool.

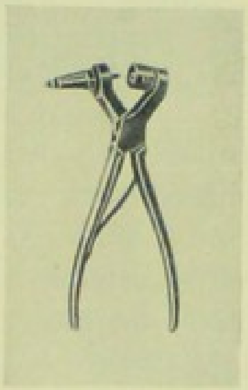


PHOTO.] [J. MURGATROYD.
FIG. 11.—Closing Tool (*one-tenth size*).

We illustrate above the eyelet buttons before and after closing (full size), and the closing tool (one-tenth size).

1. 6th I. C. on T., Vol. 4, pt. 2, p. 580.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 837.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 989.

THE STATE DEPARTMENT FOR CONTROL.

Reynolds[1] is convinced "....that the ideal State organisation for this control work consists of a Board of about five members, the majority of whom should be *ex officio*. The secretary and executive officer should be a graduate veterinarian and employed by the Board from outside its membership. The Board should be composed of practitioners and prominent owners of live stock. The members should serve without compensation or opportunity for remunerative employment by the Board. The veterinarians and live-stock memberships, in their influence on the Board, and considering the secretary, should be fairly balanced. I would not have such a Board composed exclusively of either veterinarians or live-stock men.

"This Board should be in close co-operation with the local Health Officer and Boards of Township Supervisors of the State. Professional politicians should be entirely eliminated, which is not difficult. This Board must have ample authority, and should be closely organised in connection with all the local Health Officers and Township Supervisors of the State. Its appropriations must be large and stable."

OFFICIAL VETERINARIANS SHOULD HAVE NO OTHER APPOINTMENTS.

Reynolds[2] says that "Ideal State work employs field veterinarians on full time and in exclusive service rather than deputy or assistant State veterinarians engaged in private practice."

Rutherford[3] states that "....the policy of employing local practitioners for this work has been repeatedly tried, and, in my experience at least, has not, in the majority of instances, proved either beneficial or successful."

ORDER OF PROCEDURE.

City dairy cattle

Reynolds[4] points out that the herds to attack first are those most actively spreading the infection—"city dairy cattle, creamery herds, and pure bred herds." After that the general plan would be something like that outlined by Marshall[5]: "In herds where no animals are purchased, or but few, the tuberculin re-test is applied, the reacting animals are isolated, and the stable disinfected. If a large percentage of the herd fails to pass the test, the above measure should be resorted to again in six months. Where but few reactions are found, the re-test can be deferred for one year. It is not safe to allow more than one year to elapse before making the re-test, which should be repeated yearly. In herds where animals are purchased

1. 6th I. C. on T., Vol. 4, pt. 2, p. 940.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 874.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
5. 6th I. C. on T., Vol. 4, pt. 2, p. 908.

frequently, the test should be applied at the time of purchase by a veterinarian approved by the purchaser. Animals thus tested and passed should be kept on probation for two months and re-tested before they are allowed to mingle with the older members of the herd. The stable in which these animals pass the period of probation should be carefully disinfected before they are admitted to it. The test of the herd should be applied at least once each year. In cases where many reactions are found, the test should be made every six months until a low percentage is obtained. It is not advisable to re-test too frequently. The repeated use of tuberculin may produce immunity to the test. Cases that do not react to re-test are exceptional."

As Reynolds[1] reminds us, "It is clearly established that one tuberculin test and one disinfection cannot be depended upon to eradicate tuberculosis from an individual stable, and we must plan with this in view when attempting to do thorough work."

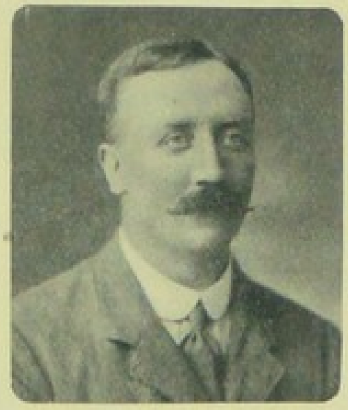
THE SCHEME OF THE MANCHESTER MEN.

Having now arrived at the possibility of securing hygienic surroundings, we may consider some practical details of setting about suppression of tuberculosis.

Brittlebank[2] proposes, first of all, to make a careful inspection of all the farms and classify them, according to the conditions found, into four divisions.

(1) Farms free from tuberculosis and of good hygienic arrangement.
(2) Farms with good sanitary conditions.
(3) Farms with medium sanitary conditions.
(4) Farms with bad sanitary conditions.

(The American score-card system would be useful in this connection, see Section III.)



J. W. BRITTLEBANK, M.R.C.V.S., D.V.S.M. (VICT.)
Chief Municipal Veterinary Officer, Manchester.

All cattle owners except those in Class 1 to be subject to a poll-tax of 1s. per head of cattle per annum. Tuberculin testing would be carried out on the farms of Class 2, and all available efforts exerted to improve those of Classes 3 and 4.

When a cattle owner passes into Class 1 he would be exempted from the poll-tax, but would receive no further indemnity. His herd having been cleared, he must maintain its purity at his own expense.

Moreover, the testing would only be undertaken by the authorities under the usual conditions that the owner will separate reacting animals and disinfect the premises. These are well established principles of procedure in American practice.

1. 6th I. C. on T., Vol. 4, pt. 2, p. 945.
2. Private communication dated Feb. 2nd, 1910.

Scheme of the Manchester men

In reference to the above scheme, Dr. Rutherford[1] said, "....I have read with much interest the plan proposed by Dr. Niven, Medical Officer of Health, Manchester, and supported by Professor Delépine and Mr. Brittlebank, the chief veterinary officer of that city, which includes the forming of disease-free islands by eradicating tuberculosis from certain farms and gradually extending the work over small districts, to be still further enlarged as the system finds favour with stock owners.

"It is....much more sensible and likely to be productive of ultimate benefit than the diffuse policy of promiscuously testing a herd here or there over an extensive territory, difficult, if not impossible, to keep under observation or control without an enormous staff of well-trained, experienced, and absolutely conscientious veterinary inspectors having no interest, beyond that of duty, in the herds which they are called upon to deal or in their owners."

VALUE OF TUBERCULAR CARCASSES.

In America "Some States hold," says Reynolds,[2] "that tubercular carcasses have no money value, others that they have a varying worth of from $15 a-piece to 40 or 75 per cent. of their market value had they not been tuberculous."

1. 6th I. C. on T., Vol. 4, pt. 2, p. 874.
2. 6th I. C on T., Vol. 4, pt. 2, p. 959.

CHAPTER VIII.

RESEARCHES IN PROGRESS.

RESISTANCE OF THE ANIMAL.

"WHILE discussing tuberculosis and its different modes of infection —by inhalation and by ingestion—and their relative frequency and dangers, it appears opportune," says Anderson,[1] "to note that this question has an obverse side which, although not so frequently commented on, is equally important, and that is the environment. In tuberculous and dirty milk there is the attacking party—the bacillus of tuberculosis and probably other pathogenic micro-organisms. But there is the defending party—the individual attacked, and with every individual must be associated the environment (housing, feeding, social, and economic habits).

Environment

"For, as a general truth, it may be said, that in proportion as the environment is good or bad, so will be the defensive powers of the individual attacked.

"We all live and breathe in an atmosphere more or less, in different places, laden with tubercle bacilli, and there must be few who have escaped at some time or other drinking tubercular milk. Yet we do not all suffer from tuberculosis. Recently, it has been clearly demonstrated that the tubercle bacillus, just like the bacillus of diphtheria, pneumonia, and others, may be found in the throat and nasal cavities of persons in perfect health, and appear to do no harm so long as health remains good and the defensive powers of the blood and tissues active and vigorous.

Tubercle bacilli in healthy throats

"Either the bacilli are prevented from gaining an entrance into the tissues and blood, or if they do gain a foothold in some wound or weak part, there is immediately thrown round them a cordon or surrounding wall of defence, and by this and many other modes of warfare the bacilli and their toxins are either annihilated, rendered harmless, or converted into innocuous products.

"The truth of this is borne out when we consider the large number of cases which reach the *post-mortem* room, in which we find, especially in the lungs and glandular structures, traces of healed scars and small areas which at one time in the life history of the individual was the scene of a battlefield between the intruding bacilli and the defending powers. In recent years many British pathologists have given this subject considerable attention, but as yet the views and statistics given by different observers regarding the probable percentage of such cases vary within wide limits. From some other countries,

1. Dr. Anderson's Rept., p. 30.

especially Germany, statistics on this point are more readily available. From statistics collected by Professor M. Hay, Aberdeen, I learn that Burkhardt, in between one and two thousand autopsies at the Dresden hospitals, found tubercle in 91 per cent. of all persons dying above eighteen years of age, and 38 per cent. among persons under eighteen years. Naegeli, in Zurich, made also an extensive number of autopsies, and found that as he became more familiar with the search for tubercle 97-98 per cent. of all the bodies of persons dying in hospital above eighteen years of age showed traces of tubercle. In persons under eighteen years of age the proportion was 18 per cent. These figures include all bodies of persons dying ostensibly of tubercular disease, as well as the bodies of persons dying from all other causes.

"Harbitz, of Christiania, who has given considerable attention to the study of pathology of tuberculosis in children, and after having performed an extensive number of autopsies, comes to the conclusion that 50-60 per cent. of all cases dying under fifteen years of age showed traces of obsolete or latent tuberculosis, occurring principally in the glandular structures.

Importance of resistance

"That the defending powers were victorious in so many cases is commemorated by the slight destruction of tissue and the healed scar; but had the former—the bacilli—been victorious, then was established in that individual, *phthisis pulmonalis*. These facts sufficiently demonstrate how important a factor, in the life history of every individual in the struggle against the microbes of disease, is the power of resistance, which again greatly depends on one's health, strength, vigour, and these, again, in their last analysis are dependent upon one's breeding and environment.

"In recent years there has been possibly too great a tendency to attack the bacillus, while forgetting that to increase the powers of resistance of the people is equally important; and this can only be done by improving the conditions under which people live, more especially in the slums and poorer districts of every town where consumption in all its forms is most prevalent. For I am convinced that, with the environment favourable as regards sanitary housing and air spaces, a plentiful water supply, and the clean water carriage system for the removal of sewage, such conditions would not only stimulate the greater number, but might even persuade the most careless to attempt to live cleanly, healthy, and vigorous lives; this, combined with the proper cooking of plain, nutritious food, and a reasonably pure milk; then, the *Bacillus Tuberculosis* will remain comparatively innocuous."

Immunity or proclivity?

Mayo[1] considers, as we have already seen, that although it is a disease which affects the majority of civilised people at some time during their lives, we have a right to say that ". . . . few serious diseases,

1. 6th I. C. on T., Vol. 2, p. 2.

not self limited, tend more naturally to ultimate recovery than does tuberculosis."

In considering the very large proportion of human subjects who survive mild attacks of tuberculous infection, Newsholme[1] points out that "....the evidence may be regarded as indicating almost universal proclivity to a certain extent, or some measures of immunity on the part of a very high proportion of the total population. The former view appears to me," this authority continues, "to be nearer the truth, as all degrees of lesions are found in the above cases, and a very high proportion of the total number of those who have suffered severely from tuberculosis recover completely and die from other diseases." Again, [2]"The fact that old localised and cured tuberculous lesions are so often found at autopsies does not appear to me to indicate that the majority of the population are naturally immune to tuberculosis, any more than it would be justifiable to state that the majority of the population are naturally immune against the three following infectious diseases, because in scarlet fever about 95 out of every 100 attacked, in enteric fever about 85, and in diphtheria 80 to 90 out of every 100 attacked, recover." Proclivity

Webb, Williams, and Barber[3] assert "The great majority of mankind must have, in some degree, a natural immunity against tuberculosis. Were it not so the race would long ago have become nearly extinct. From what we are learning from the opsonic index, this natural immunity is sometimes fortified by subsequent auto-inoculation in early infection, resulting in the healed lesions." Immunity

Commenting on the fact that 16 per cent. of the milk supply of New York is contaminated with virulent tubercle bacilli, Hess[4] states that "The very size of these figures is proof that we all, young and old, must possess a considerable degree of immunity to the infection. For it is probable that few infants fed on the ordinary raw milk do not ingest tubercle bacilli during the first year of their lives; it is, I believe, more than probable that they do so repeatedly. Furthermore, we know that children are especially susceptible to tuberculous infection, and yet tuberculosis is by no means the main factor in the high death-rate of infancy."

Pathologists are agreed that infection does not always follow on the presence of the bacillus in the body,[5] nor is the disease, says Schroeder,[6] "....as common among those persons who have been unusually exposed to infection as we naturally have reason to expect it to be. Men with tuberculous wives and women with tuberculous

1. The Prevention of Tuberculosis, p. 161.
2. The Prevention of Tuberculosis, p. 162.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 197.
4. 6th I. C. on T., Vol. 4, pt. 2, p. 528.
5. See Schroeder, 25th Annual Rept. B. A. I., p. 150; also Delépine, Pro. Roy. Soc. Med., Vol. 3, No. 7, May, 1910, Epidemiological Sect., p. 217.
6. B. A. I., Circular No. 153, p. 44.

husbands, when their family records are clean relative to tuberculosis, contract the disease so rarely that their presumably intense exposure cannot certainly be said to infect them more frequently than persons in general become infected."

The utilisation of the principle that the presence of the bacillus does not necessarily involve infection finds expression in the work of Webb, Williams, and Barber,[1] who inject small numbers of living bacilli, starting with the single organism, to stimulate immunity.

These investigators review earlier work on similar lines, and maintain that the assertion of the success of the principle has become dogmatic. This process is used on man,[2] and the lower animals notably in the case of bovines. Webb[3] and his collaborators inform us that "It is established that vaccination of calves with the human type of tubercle bacillus is harmless, and give them a relatively high resistance to fatal doses of the bovine variety."

Bactericidal power of blood

The possibility of such a process would seem to indicate a certain though small degree of natural immunity; moreover, "Behring showed that blood serum (sheep's) possessed sterilising properties far superior to those even of the stronger solutions of carbolic acid and corrosive sublimate, which were formerly employed in surgical operations."[4]

Variations in degree of natural immunity

Webb, Williams, and Barber[5] indicate, however, from their data of experiments, "....a remarkable degree of individual susceptibility and resistance to anthrax and tuberculosis" with mice and guinea-pigs, a variation which, "....no doubt," they conclude, "must be counted with in all experimental work with laboratory animals."

Thus, it would appear that susceptibility and resistance are merely degrees of the same faculty, and Newsholme's term "proclivity" may, we think, be reasonably included. The terms "immunity" and "proclivity" are, to a great extent, interchangeable, according to whether one views the positive or negative side of the propensity. None of the degrees of immunity we are discussing are complete, therefore admit of certain degrees of proclivity; while the latter term does not signify a complete receptivity to infection.

Mayo[6] states that "Many individuals have a high resistance against tuberculous infection; there are many, however, in whom the blood fails to develop the reaction which would cause the tubercle bacilli to be destroyed, thrown off, or even walled in, as usually occurs in common infections."

Kellogg[7] affirms that "The studies of Charrin, Roger, and numerous others, and especially the ingenious and illuminating

1. 6th I. C. on T., Vol. 1, pt. 1, p. 211.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 211.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 197.
4. Quoted by Kellogg, 6th I. C. on T., Vol. 3, p. 757.
5. 6th I. C. on T., Vol. 1, pt. 1, p. 208.
6. 6th I. C. on T., Vol. 2, p. 2.
7. 6th I. C. on T., Vol. 3, p. 740.

researches[1] of Wright, have shown that the essential factor in tubercular infection is the weakening of the defences of the body, the breakdown of the vital resistance in such a way as to permit the development within the body of the particular parasitic organism characteristic of this disease.....The patient who is subject to tubercular infection is ill, not because he has happened to come in contact with tubercle bacilli, but because his body has lost the power to prevent invasion of the tissues and the development therein of the tubercle bacillus and its toxic products."

Receptivity is illness

Dr. Theobald Smith[2] acknowledges the importance of the "....variations in the degree of natural and acquired immunity in the invaded host," while Bang[3] called attention to the fact that susceptibility plays an important part in the transmission of tuberculosis.

Reactive power of healthy cells

Storey[4] discusses the vital processes by which pathogenic organisms are destroyed or rendered innocuous by the body cells. "The degree of immunity," he states, "is related directly to the health of the cell. An impoverished, poorly nourished, unhealthy cell will not react to the same extent and with the same success as will the normal healthy, well-nourished cell....upon its relief from the influence of its own waste products; upon its exercise; upon its opportunities for rest and repair; and upon a reasonable freedom from the direct and indirect influences of pathogenic organisms. These facts have everywhere been forced upon the attention of men who are experimenting with the immunity reactions of the blood. They find healthy blood is necessary for good reactions.

"Bactericidal phenomena, phagocytosis, bacteriolysis, agglutination, the productions of antitoxins, and the other phenomena of immunity are all more marked in blood taken from healthy animals.

"It has been found in laboratories everywhere that a reduction in mortality and a more successful experimentation with the vital phenomena of cellular structures in experimental animals accompany the provision of good and sufficient food, exercise, and careful sanitation."

Schroeder[5] says: "We know that tuberculosis is a disease that develops with a peculiar frequency during those periods of life when the drain on the mental and physical forces is greatest, rather than during periods following incidents of exceptional exposure to infection."

Anders[6] inquires "Shall we lay the major, if not the exclusive, stress upon the menace of the microbe....or shall we make mere incidental reference to the seed and its implantation possibilities and probabilities, but rather expound the receptivities of the soil, and show forth and warn against the various enervating agencies of

1. Power of the blood resistance to disease as measured by opsonic index.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 651.
3. 6th I. C. on T., Vol. 4, pt. 2, p. 610.
4. 6th I. C. on T., Vol. 3, p. 770.
5. B. A. I., Circular 153, p. 44.
6. 6th I. C. on T., Vol. 3, p. 615.

domestic, industrial, and social life, which so readily induce the bacillary insemination of that soil ?

Fortify the body

[1]" The mastery over tuberculosis is not to be gained so much by the, at present, obviously fruitless and almost impossible attempt to eradicate the bacilli by sanitary laws, rules, and regulations, but by fortifying, to the point of impregnability and invulnerability, the tissue cells and chemico-physiological forces of the body by carrying out daily the simple practices of an invigorating hygiene....[2]rather than along those of bacterial communicability....my vote is for the body."

Newsholme[3] quotes the following words of J. Kingston Fowler,[4] " Although infection must be regarded as the *causa sine qua non*, it is not necessarily of most importance from a practical point of view. If of a large number of persons exposed to infection only a few acquire a disease, the susceptibility of the individual becomes a factor in causation of greater moment than exposure to infection."

" Breed health, seek health, keep health," says Dr. William Watson,[5] " and there is no danger from the tubercle bacillus."

Unterberger[6] concludes that " We must, of course, seek to destroy the tubercle bacillus as far as possible, but it is Utopian to imagine that all the tubercle bacilli in the world can be annihilated. Our chief endeavours must, therefore, be directed toward strengthening the body." Dr. Pickett Turner,[7] however, thinks that " If man cannot vanquish a microbe, there must be something wrong in his methods."

Immunity of civilised races

Increased Immunity of Civilised Races.—Dr. Herbert Decarle Woodcock[8] (Leeds, England) points out that "....natural immunity is obtained only by contact with disease, not by isolation from disease.

" The Anti-tuberculous Society of Trinidad," he continues, " has recognised this in a brightly written report in which it is stated that the ' African fresh from his forest bed of leaves dies if brought into close contact with the disease,' when the white man of old civilisation does not succumb. The Irishman, living away from cities dies when introduced to city life. The Jew, the ancient race which has been forced by tyranny to live in slums for more than one thousand years, is now much more immune to the disease than is the case with other races ; yet if the Jew is introduced to conditions worse than he has been accustomed to, he succumbs.

" In Leeds, England, there are thirty thousand Jews ; they have the worst dwellings in the city—the parts of the city refused

1. 6th I. C. on T., Vol. 3, p. 616.
2. 6th I. C. on T., Vol. 3, p. 618.
3. The Prevention of Tuberculosis, p. 162.
4. Diseases of the Lungs, p. 305.
5. Lecture before the Glasgow and West of Scotland Agricultural Discussion Society. See The Scottish Farmer, Nov. 19th, 1910, p. 1034.
6. 6th I. C. on T., Vol. 1, pt. 1, p. 141.
7. Tuberculosis: Its origin and extinction, p. 3.
8. 6th I. C. on T., Vol. 2, p. 513.

by the English artisan. They confine themselves to the clothing trade, a trade dusty, unhealthy, carried out often under insanitary conditions, causing phthisis among all races engaged in it.

Immunity of Jews

"The immunity of the Jew to phthisis has broken down to some extent in Leeds. Yet with all this the Jew is superior in health record and in physique to the Gentile in the same state of life, *i.e.* in Leeds. This superiority of physique is especially noticeable in the young. Woodcock examined a school and found one half with the Calmette reaction. All these children have defects in nose and throat. In an English artisan club he finds a large number of defects in nose, throat, and teeth among the members. He examines the same number of Jewish club members (eighty in each club), and does not find the defects in nose, throat, and teeth. Only the general results show that the more immune race had the normal nose and throat; the Jewish palate (hard) is dome-shaped, for instance."

In conclusion, he said "that if you isolate people from insanitary surroundings, you must supply an artificial immunity to take the place of the natural immunity obtained by the elimination of the unfit. In all the splendid philanthropy of our country we must remember this, otherwise by complete isolation of peoples we shall retrograde in immunity."

Leupp[1] discusses a similar retrogression in Indians.

Newsholme[2] is unwilling to cede to this principle any part in a reduction of the disease where such reduction has occurred. He cites Ireland as an example of a country where the survival principle has failed to reduce tuberculosis.

It does not appear that Woodcock regards the Irishman as completely urbanised, however, as we see from his words above, therefore, that the survival principle has not come fully into operation.

Hypo-immunity of Irish race

Fishberg,[3] also Flick,[4] takes the same view. The latter authority attributes the hypo-immunity of the Irish race to the fact that they were not conquered by the Romans, and for a much longer period than the other races of Europe avoided contact with them.

Hutchinson[5] concludes that "....such immunity as may be acquired by civilised races is probably like the immunity of the negro races to malaria—the result of the survival of attacks of the pulmonary form of the disease in childhood."

Dissipation

In the case of the Indian, however, the argument is complicated, as shown by Leupp,[6] by the fact that the Indian's former healthy occupations have gone, giving place to idleness. Moreover, "....the bad liquor which the white man has taught him to drink, to say nothing

1. 6th I. C. on T., Vol. 4, pt. 1, p. 428.
2. 6th I. C. on T., Special Vol., p. 81.
3. 6th I. C. on T., Vol. 3, p. 425.
4. 6th I. C. on T., Vol. 3, p. 475.
5. 6th I. C. on T., Vol. 2, p. 421.
6. 6th I. C. on T., Vol. 4, pt. 1, p. 429.

Inter-marriage

of the other vices which follow in the wake of civilisation, contributes in large measure to his further physical undoing." Hrdlicka[1] adds the influence of close intermarriage rendered necessary, especially in the smaller tribes, by the system of reservations.

VACCINATION.

Immunity

The ancients believed in the principle that one attack of an infectious disease diminished the risk of a second infection. Increased knowledge and experience has strongly confirmed this belief, so that we are now conversant with the phenomenon, not only in the individual, but also as a racial hereditary characteristic. Indian hill tribes, for instance, [2]"....live healthily in malarious localities, which are fatal not only to Europeans but to Hindus," and it is a matter of common experience that all living creatures " get used to " abnormal conditions.

A little reflection leads one to see that this acquisition cannot be due merely to the repetition of the adverse influence, but must be the result of the adaptability of the system in fortifying itself in some peculiar way against a possible repetition. That such is actually the case can be demonstrated experimentally. Webb, Williams, and Barber[3] have shown, for instance, that although a few hundred tuberculosis bacteria injected into the blood stream of a guinea-pig will rapidly produce death, another animal may sustain a few thousand without any inconvenience if it has previously received smaller doses at intervals, commencing, for safety, with a single bacillus.

Mithridatism

The drug habit among humans, notably the arsenic eating of the Tyrolese and the opium eating of the Chinese, affords concrete examples of another class, but here we must draw a sharp distinction between racial and individual acquired immunity. There is no evidence to show that immunity acquired during the lifetime of an individual, or indeed any acquired characteristic, is transmitted to the offspring, and racial immunity is explained completely on the lines of the survival of the fittest—that is, only the more immune individuals survive, hence in time the race is comprised of the selected strains.

Ehrlich[4] has shown, however, that when mice are immunised against ricin, the highly poisonous protein (albuminoid) of castor seed, the offspring show a similar immunity ; but this is believed to be effected through the mother's milk. The possibility of a similarly transmitted, but lower degree of, immunity is contemplated (see p. 170) in relation to the children of tuberculous human mothers.

One naturally wonders how far the process of racial immunity has developed in bovines. Professor Sir John M'Fadyean[5] assures

1. 6th I. C. on T., Vol. 3, p. 489.
2. Bibby's Quarterly, Oct., 1896, p. 20.
3. 6th I. C. on T., Vol. 1, pt. 1, p. 207.
4. Quoted by Sternberg, Infection and Immunity, p. 81.
5. Jour. R. A. S. E., 1910, p. 36.

us, however, that "From the breeder's point of view these points are devoid of practical importance, because the highest degree of insusceptibility possessed by any bovine animal is inadequate to enable it to withstand ordinary risks of infection; and further, because there is no practicable method by which an owner, with a view to selection for breeding purposes, can ascertain which of his animals possess powers of resistance above the average."

Jenner observed that people who milked cows appeared less afflicted with small-pox than others. Naturally, he wondered what the cows had to do with this. He ultimately arrived at the conclusions that cow-pox was the bovine form of small-pox, and that the slight illnesses which the milkers contracted by association with cow-pox served to protect them against the more virulent human disease. If an attack of cow-pox will protect a man against small-pox, he argued, the sooner the man has cow-pox the better.

Smallpox and cowpox

The transmission of the disease from the cows to the milkers he believed to occur through the breaking of the characteristic pustules which smeared the hands of the milkers with the virus. Accordingly, he produced the virus in quantity, termed it "vaccine," and inoculated human beings with it, hence vaccination.

Antitoxins

Dr. Pottenger[1] tells us that "....it is said on good authority that it is possible to vaccinate with small-pox against cow-pox." The conception that immunity or resistance to disease was a condition which could be induced or developed grew apace, and the mechanism of how it came about rapidly claimed the attention of the most distinguished investigators.

It gradually became revealed as a question of action and reaction that the blood fortifies itself against the invading poison. How does it fortify itself? It appeared that the fortified blood contained constituents which were lacking in the susceptible blood, and so the belief in antitoxins arose. Why not make antitoxins and introduce them into the blood? Can we make an antitoxin for any disease? Can we mix the antitoxins and inoculate an animal so that it will be proof against several diseases, or can we stimulate the animal to make its own antitoxins? These were the questions that presented themselves to the pathologist in his struggle against disease.

Complex and difficult as all problems connected with life processes are, it was found that human power of observation was competent to unravel some mysteries and arrive at solid facts—that properties of blood were demonstrable as chemical reactions, and the persevering investigator essayed to grapple with their *rationale*.

Finding ourselves unable to avoid the virus of disease, we sought to entrench against attack—to acquire immunity, so that man is now anxious and willing to exchange these powers with his fellow animals—one more step towards the ultimate unity of things.

1. 6th I. C. on T., Vol. 1, pt. 2, p. 803.

If a guinea-pig can be fortified against an ordinary fatal dose of tuberculosis, why cannot a man also be protected, and why not our other domesticated animals? It would seem to be only a matter of knowing the right way to do it. It is certainly worth while. We must not be daunted by failures. It is a struggle between the limited ingenuity and wit of man against the mysterious intricate processes of Nature. So many minute forms of life are struggling around us, all legitimate enough in their own sphere, but they are antagonistic. We must either hold our own or go under.

Schroeder[1] tells us "The immunisation of cattle against tuberculosis is a subject upon which investigators have been working for a number of years, with results that have inspired the hope that we shall have in the near future an additional means of combating the disease, and one that will greatly strengthen our present resources. The papers which have recently been published on this method of prevention, together with the discussions at the International Veterinary Congress held in Budapest in 1905, show that the ablest veterinarians in the world are confidently expecting that a practical and safe plan of procedure will soon be developed. If this expectation is fulfilled, the operations against tuberculosis will not only be materially simplified, but the expense involved in the eradication of the disease and the loss falling upon the individual owners will be vastly reduced.

"A method of prevention which promises so much is deserving of very careful consideration, even at this early stage of its development, for undoubtedly we shall soon be called upon to pass judgment as to its practicability. If it can be safely applied and is effective, it should be adopted and utilised as soon as it is perfected; but if, on the other hand, it is neither safe nor a satisfactory preventive, these facts should be made known as soon as possible. The value of the method can only be estimated when we have some knowledge of the investigations which have led up to it, and when we fully understand and appreciate the dangers which must be avoided."

Still continuing from Salmon's excellent paper, we shall give a short résumé of the earlier work on the attempts at immunisation.

As long ago as 1889 Daremberg[2] made experiments by inoculating guinea-pigs and rabbits with dead cultures of the tubercle bacillus. Some of the rabbits showed considerable resistance to the disease, as compared with similar animals which had not received the preventive treatment.

In the same year Grancher and Martin[3] announced a reliable method of attenuating (weakening) the tubercle bacillus. They produced cultures of ten degrees of virulence. They believed that they had succeeded in giving to rabbits the power of a prolonged

1. Quoted by D. E. Salmon, D.V.M., B. A. I., Bull. No. 38, p. 53.
2. Bull. de l'Acad de Med., Paris, ser. 3, t. 22, pp. 391-404. Paris, 1889.
3. Bull. Med., Ann. 4, p. 777. Paris, 1890.

resistance against the most rapid and the most certain experimental tuberculosis, and that they had also succeeded in conferring upon these animals an immunity against this same disease the duration of which remained to be determined.

In 1890 Trudeau[1] concluded that preventive inoculation with an attenuated living germ, or with a form of tuberculin, failed to confer immunity. In 1894 this investigator[2] showed that rabbits which survived the subcutaneous inoculation of living cultures of the avian tubercle bacillus of gradually increasing virulence, and in graded doses, undoubtedly acquired a certain degree of immunity against subsequent eye inoculation with mammalian cultures. He also found that while the rabbit, which is very much more susceptible to the avian than to the mammalian bacillus,[3] may acquire a certain degree of immunity against the latter by preventive inoculations of the former, the guinea-pig, which can rarely and with great difficulty be killed by the avian microbe, is in no way protected by this treatment.

In 1894 De Schweinitz[4] concluded that attenuated tubercle bacilli may possibly prove very valuable in checking or controlling tuberculosis in animals, especially cattle.

The investigation was continued in collaboration with Schroeder.[5] They showed the possibility of immunising cattle, having vaccinated a cow with gradually increasing doses of their attenuated bacillus, ultimately using nearly two quarts of the suspension. This cow was then injected with virulent material taken from a cow affected with generalised tuberculosis. Seven months afterwards the cow was killed, and a careful autopsy, made by Dr. Schroeder, failed to disclose the slightest evidence of tuberculosis.

M'Fadyean[6] published some interesting experiments in 1901, which seemed to show that the animals used in his experiments had acquired a high degree of immunity.

In 1902 Pearson and Gilliland[7] concluded that the administration of Koch's original tuberculin had some effect in increasing the resistance of cows to infection from feeding tuberculous material.

Inoculations of two animals with human tubercle bacilli grown from sputum cultures failed to produce general tubercular infection, even when large doses were employed, and in the case of one of

1. Med. Rec., Vol. 38, No. 21, pp. 565-6, N.Y., Nov. 22nd, 1890.
2. Trans. Assn. Am. Phys., 9th Session, Vol. 8, pp. 168-73, Phila., 1894.
3. The British Royal Commission state: "Moderately large doses of the avian bacillus, though fatal by inoculation to the rabbit, are less virulent than the bovine, but more virulent than the human tubercle bacillus" (Final Rept., p. 7). (Bovine and human are both mammalian.)
4. Med. News, Vol. 65, No. 23, pp. 625-9, N.Y., Dec. 8th, 1894.
5. B. A. I., Bull. 13, pp. 11-14, Wash., Sept. 19th, 1896.
6. Jour. Comp. Path. and Ther., Vol. 14, pt. 2, p. 136, June, 1901; also Mar., 1902.
7. Jour. Comp. Med. and Vet. Arch., Vol. 23, No. 11, pp. 673-88, Phila., Nov., 1902.

the animals the normal resistance to virulent bovine bacilli was increased.

Von Behring[1] published his first paper on the subject in 1901. His method has been modified from time to time, but "....he has, no doubt," says Salmon, "succeeded in producing a high degree of immunity in some of his experimental animals."

Some important experiments were made by Hutyra[2] under commission of the Hungarian Department of Agriculture, to determine to what extent vaccination according to von Behring's method increases the immunity of cattle against artificial infection with virulent bovine tubercle bacilli.

Hutyra[3] concluded that resistance is increased to a very considerable extent, but that more extensive experiments were necessary to determine how long this condition lasted.

Experiments made by Thomassen[4] in 1902 indicate that considerable immunity may be produced by inoculating cattle with human bacilli.

Klimmer[5] attenuated the tubercle bacillus by passing it through cold-blooded animals (carp and salamander), and produced immunity by its inoculation in rabbits, guinea-pigs, and calves. He also used non-virulent human bacilli. On a royal estate near Dresden, over 80 per cent. of the cows and over 40 per cent. of the young cattle reacted to tuberculin. Immunisation of calves was shown to be without danger and to confer marked immunity. Of about sixty calves treated, some have been slaughtered and others have died from various causes, but in none of these could signs of tuberculosis be discovered. Neither have any of the immunised animals reacted to tuberculin. They developed in a superior manner. All experimental animals were stabled among the tuberculous animals and, therefore, exposed to a heavy infection. Of the control calves, which, of course, were not immunised, fourteen were tested at one time and six reacted. At another time ten were tested and three reacted.

Koch, Schütz, Neufeld, and Mieszner[6] conclude that they have succeeded by a single vaccination with 1 to 3 centigrammes of bacilli of human tuberculosis or of attenuated bacilli of bovine tuberculosis in producing in cattle an immunity against highly virulent bacilli of bovine tuberculosis. The bacilli as used up to this time and grown upon glycerine bouillon must be from thirty to forty days old. They are dried between blotting paper and the required amount is mixed with 10 c.c. of physiological salt solution (solution of one-fifth of 1 per cent. of salt in water) and injected into the veins.

1. Beit. z. exp. Ther., Hft. 5-8, Berlin, 1902-04.
2. Beit. z. exp. Ther., Hft. 9, pp. 1-17, Berlin, 1905.
3. 8th Inter. Vet. Congress, Budapest, 1905.
4. Rec. d. Méd. Vét., t. 80, No. 1, pp. 5-19, Paris, Jan. 15th, 1903.
5. Berl. Tierärztl. Woch., No. 37, pp. 465-9, Berlin, July 5th, 1905.
6. Archiv. für Wiss. u. Prakt. Thierheilkunde, Bd. 31, H. 6, pp. 545-75, Berlin, Aug. 5th, 1905.

Professor Vallée[1] controlled experiments under the auspices of the Société de Médicine Vétérinaire Pratique by Professor von Behring's method. Five out of six of the vaccinated animals developed no lesions when tested by intravenous inoculation, whereas the checks died or became tuberculous; five of the seven tested by subcutaneous inoculation were immune, whereas the checks all had extensive lesions in the neighbouring glands and several had generalised lesions in the lungs and annexed glands; and, finally, all of the vaccinated animals successfully resisted the test by cohabitation, which is the usual method of infection, whereas the check animals all became tuberculous. Vallée concludes that it is experimentally possible to confer on young bovine animals a high degree of immunity in regard to tuberculosis. The duration of the immunity is being tested by further observation.

After reviewing the investigations of which the foregoing is a short abstract, Salmon[2] concluded (1906) that "....great progress has been made in the development of a method for immunising cattle against tuberculosis. The results of the different tests up to this time have not been as uniform as is desirable, but they are constantly improving in this respect, and there is good reason to expect that a safe and effective method will soon be available.

"This method of protecting cattle from tuberculosis is still so new, and has been used so little under practical conditions, that it should only be adopted by the cattle owner with much caution and under expert veterinary supervision. There is still much to learn about these 'vaccines' and their effects, and the owner of cattle will be wise to avoid their use pending further investigations, except in the most urgent cases and under conditions where such treatment is clearly indicated."

[3]"The immunisation of cows, assuming that investigations show that this may be successfully accomplished, would raise the question as to the danger which this method might cause to the consumer of the milk. The immunising material is the human tubercle bacillus which has not been deprived of all its dangerous qualities, and when this is injected into the blood it causes an elevation of temperature and perhaps other signs of illness. Is there danger of this bacillus contaminating the milk during the period that it is circulating in the blood of the animal? And, further, does the illness caused by the immunising dose of the vaccine have any injurious effect upon the composition of the milk which might render this liquid injurious to the consumer? These are questions of a serious nature, and they should receive a scientific answer before the immunisation of milk-producing cows is practised."

1. Basset J. Rec. d. Méd. Vét., t. 82, No. 23, pp. 815-9, Paris, Dec. 15th, 1905.
2. B. A. I., Bull. No. 38, p. 71.
3. B. A. I., Bull. No. 38, p. 88.

Von Behring's researches

In discussing the experiments along this line, Professor Dewar,[1] speaking at the Ninth International Veterinary Congress at the Hague, 1909, stated: "One of the first and most prominent of these experimenters has been Dr. von Behring. He found that intravenous inoculation of animals with cultures of human tubercle bacilli conferred a considerable amount of immunity. His method was tried by our French confrères in what came to be known as the Melun experiments in 1904-5, and at first they were very sanguine about it. In summing up an account of them, Professor Vallée stated: 'These experiments prove, therefore, that the vaccination of cattle against tuberculosis by the method of von Behring is an accomplished fact, and deserves to be used in everyday practice.'

"Knowing the eminence and ability of these independent experimenters, it was little wonder if we were inclined to believe that a new era had dawned in connection with our methods of dealing with tuberculosis. But it was soon evident that we had all been too sanguine, and before a year had passed we find MM. Rossignol and Vallée expressing themselves regarding this method of inoculation thus: 'The resistance of vaccinated animals to natural contagion, such as results from cohabitation in the byre, is little marked, and is not prolonged beyond some months.'

"As if that were not sufficient to cool the ardour of the most enthusiastic disciple of von Behring, we find Professor Moussu criticising the method in something like the following terms: 'The method of bovo-vaccination remains inefficacious and without practical value; it is dangerous. The bacilli of inoculation have been found living and virulent six months after vaccination, and capable of communicating tuberculosis to guinea-pigs by inoculation.' Perhaps we expected too much. In any case, after the manner in which our hopes had been raised, our disappointment was considerable. However, it was only a comparative failure, and stimulated to fresh effort. All the world knows of the agreement between Professor von Behring and the Government of Argentina, in which he undertook to demonstrate that he could treat successfully animals affected with tuberculosis by means of a vaccine which he termed 'Tulaselaktin,' and equally well known is the complete failure of the remedy. The Commission appointed to supervise the experiments state in their conclusions: 'The Tulaselaktin has not brought about either the cure or the retrogression of the tuberculous lesions in the cattle to which it has been applied.' To all appearance it could not have had a more complete or fairer trial, and its failure is only one more proof of the difficulty of dealing with tuberculosis.

Failure of Tulaselaktin

"A VACCINE."

Risk with virulent vaccines

"In trying to find a satisfactory vaccine, the danger of using living tubercle bacilli, of any type or variety, should not be lost sight of.

1. The Scottish Farmer, Nov. 6th, 1909, p. 926.

Thus, with bacilli of the human type, which, it seems, may remain in the organism of the vaccinated for six months or more, there must be in the case of cows a risk of these bacilli finding their way into the milk, and proving a source of great danger should it be consumed in the fresh state. The same holds good with the flesh of animals vaccinated. No animal could be safely slaughtered until at least six months after being vaccinated, as living virulent bacilli might be scattered throughout the muscles and various organs of the body. And should a vaccinated animal meet with any accident necessitating slaughter, the carcass would have to be destroyed. No doubt all risk could be avoided by the thorough cooking of the meat and organs used as food, but they could not be put into the market in the usual course. Then, if the immunity conferred, whether partial or complete, is only temporary, and requiring the vaccination to be repeated annually, it could scarcely ever be said with absolute certainty that there was no risk of the animal harbouring living virulent tubercle bacilli. And with a vaccine containing living tubercle bacilli, more so if they are bacilli of human origin, there is always some risk to the operator and to his assistants while performing the vaccination. The first time I used a vaccine containing living bacilli for intravenous injection, I caught myself blowing a blood clot out of the needle of the syringe. To say that it was an example of gross carelessness does not alter the fact. It shows, at least, that the danger is not imaginary. But attempts are being made, with more or less encouragement, to obtain vaccines that are non-virulent, and Professor Klimmer seems to claim that he has already achieved success—yet his vaccines contain living tubercle bacilli, and while their virulence has been weakened, and they have been rendered non-pathogenic for our domestic animals, they still maintain their vitality, so that the possibility of their regaining to a great extent their original virulence must be considered.

Non-virulent vaccine

"THE FARMER'S PART.

"The efforts to find a satisfactory vaccine, however, presuppose the continued existence of tuberculous animals amongst the vaccinated. The farmer, the stock breeder, who has successfully eliminated tuberculosis from his herd, who has removed all possibility of contagion, has no need to vaccinate his animals, and there is no doubt but the total elimination of the disease is far better than the keeping of it under considerable control by means of vaccines, however safe they may be."

A pessimistic view was expressed early in the Sixth International Congress on Tuberculosis at Washington, 1908, by Rutherford.[1]

Mohler and Washburn,[2] in summarising the procedure of various investigators previous to 1908, state that while the "....methods were different, their systems of operation were based upon similar

1. 6th I. C. on T., Vol. 4, pt. 2, p. 876.
2. 6th I. C. on T., Vol. 4, pt. 2, p. 635.

processes, that is, they all injected the calves[1] with tubercle bacilli having a low degree of virulence, using bacilli having either human or bovine origin. The differences which existed in their several methods were to be found mainly in the manner of administering the injections, and in the number of applications considered necessary for the production of adequate protection of the animal. There was also some difference in the preferred age at which the calves were to be treated."

In comparing the methods of von Behring and Pearson (see p. 392), Noack[2] is "....satisfied that Pearson demands the removal of tubercular animals from the herd before vaccination, and reduces the danger of infection to a minimum."

Active and passive immunity

Artificial immunity may be of two kinds[3]: "In active immunisation the organism has to produce specific antibodies in the serum, as the result of the absorption of bacteria or their products; on the other hand, in passive immunisation these are already produced in some other organism and introduced into the human body by means of a specific serum." It will be seen that in the experiments on bovines, the work has been along the line of active immunity. The work of Professor C. O. Jensen, in immunising calves against white scour (see p. 432), is an example of passive immunisation; as also the practice of Raw[4] in immunising human subjects who have been exposed to infection, as, for example, children from a consumptive father or mother, with the serum of tuberculous cattle.

Mayo[5] considers that "In the animal world the results are extremely gratifying."

It is interesting to note that the Bureau of Animal Industry[6] are working on the immunisation of cattle and hogs, and in Maine Deering[7] is watching the results of the vaccination of 100 calves.

THE VACCINATION OF CATTLE AGAINST TUBERCULOSIS.

ABSTRACT OF PAPER BY LEONARD PEARSON, V.M.D.,[8] STATE VETERINARIAN, PHILADELPHIA, PA.

"It is now established that the resistance of cattle to infection by the tubercle bacillus may be increased by vaccination with living tubercle bacilli of the types that produce natural infection in mammals. It is necessary that the culture used for vaccinating shall be of such low virulence as to be non-pathogenic for the species of animal upon

1. "Injected into jugular vein" (Noack, 6th I. C. on T., Vol. 4, pt. 2, p. 994).
2. 6th I. C. on T., Vol. 4, pt. 2, p. 994.
3. Dr. Nathan Raw, The Lancet, Mar. 26th, 1910, p. 845.
4. 6th I. C. on T., Vol. 1, pt. 2, p. 786.
5. 6th I. C. on T., Vol. 2, p. 3.
6. See Mohler and Washburn, 6th I. C. on T., Vol. 4, pt. 2, p. 635.
7. 6th I. C. on T., Vol. 4, pt. 2, p. 916.
8. 6th I. C. on T., Vol. 4, pt. 2, p. 1002.

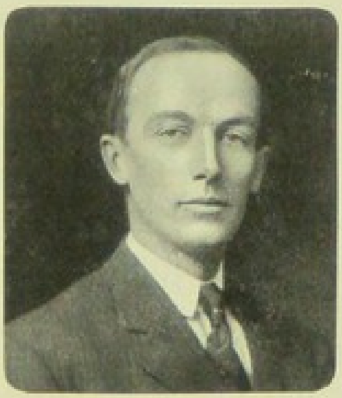
which it is used. It does not seem to be proved that tubercle bacilli from birds will produce immunity in mammals, nor has it been possible to produce a material or serviceable degree of immunity by the use of dead tubercle bacilli or extracts.

"The best results, thus far, have come from the use upon cattle of cultures of human origin and type. The vitality of the vaccine is important. Any drying or grinding process that kills a part of the tubercle bacilli, or weakens them, lessens the efficiency of the vaccine.

"The degree of immunity is proportional, in large measure, to the extent of vaccination, *i.e.* to the number of times vaccinated, the dosage, and the period of time recovered. The duration of resistance is from one to three years.

"Vaccine may be administered subcutaneously or intravenously. To give to cattle by the mouth cultures of tubercle bacilli that are virulent for man, or for any domestic animal, as swine, is not to be recommended in practice.

THE LATE DR. LEONARD PEARSON, B.S., V.M.D.
Formerly State Veterinarian, Pennsylvania.



DR. SAMUEL H. GILLILAND, V.M.D., M.D.
State Veterinarian, Pennsylvania. Co-worker and successor to Dr. Pearson.

"The method of administering a vaccine in a capsule inserted beneath the skin, as proposed by Heymans and extensively used by him in Belgium, appears to be promising, and should be tried in comparison with other methods.

"To restore immunity after it has disappeared, in milking cows, one should not use a vaccine that is virulent for man, unless it shall be established, beyond doubt, that there is no possibility that any of the bacilli so introduced are excreted through the udder. But it appears that a virulent culture may be used for this purpose. Klimmer's work with such a culture is most valuable. A disadvantage of vaccination by the intravenous method is that it is followed by a short negative phase or period during which resistance to infection is diminished. Hence, it is necessary that cattle so vaccinated shall be carefully protected from exposure during the whole period that they are undergoing vaccination, and for at least six weeks thereafter. Another disadvantage is that for as much as six months after vaccination, and sometimes longer, there is a hyper-sensitiveness to tuberculin, so that one is not in position, by the use of the tuberculin test, to determine whether the animal is or is not infected with tuberculosis.

"By the combined use of a modification of the Bang system and vaccination, it should be possible to control tuberculosis in herds where the Bang system in its entirety is not practicable."

Eastwood[1] quotes further particulars of Pearson's work as follow: "For several years the question of vaccinating cattle against tuberculosis has engaged the attention of the State Live Stock Sanitary Board, and an experimental herd, containing over 100 animals, has been established for the purpose of studying the value of this method. The vaccine used is a slightly virulent virus isolated from the sputum of a consumptive girl. It is of rather low virulence for guinea-pigs, is not virulent for rabbits, and has never been known to cause infection in cattle unless given in enormoús dosage to young calves. The method employed is to administer intravenously three successive doses of living bacilli at intervals of from six to eight weeks. In September, 1906, Dr. Pearson reviewed the results of the work, and wrote: 'Not one animal that has been vaccinated in accordance with the method that we are now using....has become tuberculous from natural exposure to the disease, nor has an animal been injured by vaccination. With such evidence, covering four years and a large number of cattle, we have felt that we are amply justified in recommending vaccination and in applying it in practice....It is planned to introduce it gradually, using it at first where it is most needed and where the conditions are such as to give it a fair trial....It is for the present applied only by specially trained men from the State Laboratory. Cattle have been vaccinated in nearly all parts of the State, and the method is having a chance to prove its worth under widely varying conditions....It is quite premature to apply vaccination against tuberculosis promiscuously—to exploit it commercially....This control should not be left in the hands of a commercial house interested in placing the greatest possible amount of produce on the market.... Vaccination against tuberculosis is free in this State so far as the resources of the State Live Stock Sanitary Board will permit. The process is useful in all breeding herds where there is tuberculosis, and by its use, sound animals can be produced from tainted ancestry more easily and surely than by the Bang method, and their continued freedom from infection can be insured. Already prospective buyers are inquiring of me as to where they may find vaccinated cattle, and this preference is likely to increase and to develop a definite market demand.'"

In Massachusetts "Dr. Pearson," according to Eastwood,[2] "has done a great deal to stimulate interest in vaccination against

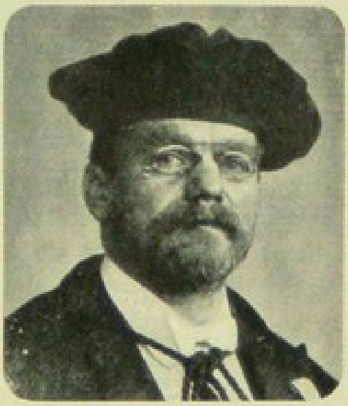
1. Dr. Eastwood's Rept., p. 9.
2. Dr. Eastwood's Rept., p. 12.

tuberculosis, and in many parts of the States I have heard favourable opinions of his work. The method of keeping down tuberculosis by means of vaccine treatment is very commonly spoken of as 'The Pearson method.' At a large dairy farm which I visited in the State of Maryland I was told by the owner, who was exceptionally well informed and enterprising, that the elimination of tuberculosis from his cattle was largely due to the vaccine treatment which had been carried out under the direction of Dr. Pearson. Results such as these are distinctly encouraging; but it seems safest, at present, to regard the method as still on its trial, and to remember that its reliability has not been substantiated on so extensive a scale as has that of the Bang method."

VACCINATION AGAINST TUBERCULOSIS IN CATTLE.

The following is an account of the address and discussion of the distinguished Belgian investigator, Professor Heymans, at the Sixth International Congress on Tuberculosis, Washington, September, 1908.

As workers in this important subject, Heymans mentions Koch, von Behring, Schütz, von Baumgarten, Lignieres, Friedmann, Calmette, Vallée, and Arloing.



J. HEYMANS
Professor of Therapeutics and Pharmacology, Medical Faculty, Ghent.

In dealing with vaccination against tuberculosis, Heymans at the outset acknowledges that one must take into consideration the possibility, both in humans and animals, of acquired immunity or eventual healing. That healing does take place so that death is averted no one denies.

That a superinfection does not produce nearly the same active tubercle formation as an original infection can easily be proved experimentally. "That sound cattle brought into a diseased stable, vaccinated once, exposed for years in the same stable to the same infection, show, on dissection, only encapsulated and calcified tubercular lesions of the first infection, or no lesions at all I have," continues Heymans, "like others, often observed a few bacilli introduced into the respiratory or digestive tract of sound cattle or human beings are sufficient to cause the formation of tubercles; on the other hand, a lung affected with open tuberculosis can eliminate, day in and day out, masses of bacilli, unless the new tubercles occur in the sound part of the lung, in the larynx, in the alimentary canal, etc. These and many other reasons prove beyond doubt that the organism under the influence of tuberculosis is distinctly more resistant to continued tubercle formations; therefore, an increased resistance or immunity against repeated bacillary infections exists, and this reaction of the organisation can, and does, lead to a perfect encapsulation and healing of the infection which has taken place.

"The problem of vaccination against tuberculosis must be solved, just as it has already been solved for small-pox, by the production of a vaccinating tubercle with all the advantages, but without the disadvantages, of spontaneous tubercle; and it will be solved if we bring the organism to be vaccinated and the vaccinating tubercle bacillus in such a counteraction that no progressive tubercular infection occurs. To produce this reciprocal state we have proceeded in the following way:—

"We fill about one milligramme of living bacilli diluted with powder—which quantity and type of bacilli furnish the best results is not yet decided—into a small reed sac, which is closed and, for safety's sake, collodionised.[1] This little bag is introduced under the skin of the animal."

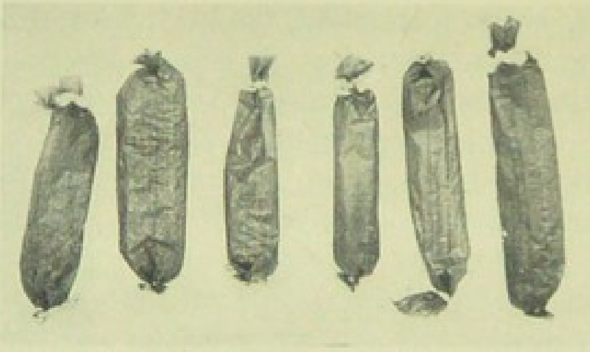


PHOTO.] [J. MURGATROYD.

FIG. 12.—Reed Sacs, containing living tubercle bacilli, used by Professor Heymans for vaccination of cattle against tuberculosis. (*Full size.*)

Professor Heymans here demonstrated the operation at the Congress. "That the sac brought under the skin can, and does, vaccinate appears from the following facts: I introduce 0·5 c.c. of raw tuberculin into a sac and allow it to diffuse in 5 c.c. of physiological salt solution for twenty hours, inject these 5 c.c. into a tubercular animal. The latter reacts typically. Tuberculin diffuses also through the intact membrane of the sac, as one can judge from the colour of the tube [handed round]. 0·5 c.c. of glycerine bouillon, placed in a sac, is inoculated with tubercle bacilli, and the sac placed in a flask containing 50 c.c. glycerine bouillon. The bacilli develop in the incubator to a compact cylindrical column which fills the lumen of the sac from top to bottom. [Three flasks shown in demonstration.] It can now be shown that the bouillon in which the sacs hang contain the toxins of the tubercle bacilli—tuberculin—just as if the organisms had developed freely into a thick skin on the surface of the medium with the whole of it at their disposal for nutrition and secretion. When one of these sacs is introduced under the skin of an animal, it acts just

1. Professor Heymans has since informed us that he has ceased collodionising the reed sacs, the process rendering the sacs too impervious.

as in the incubator. A tubercular animal reacts typically if one places under the skin a sac containing 0·5 c.c. crude tuberculin. On the other hand, if a sac containing bacilli is brought under the skin, the bacilli contained in it continue to thrive and increase, as may be shown by microscopical examination, as long as nourishment is within their reach. That the organisms remain alive is shown by infection of guinea-pigs. They continue, therefore, to transfuse the vaccinated animal the specific excretions until the latter have completely exercised their bactericidal action, *i.e.* as long as there exists insufficient immunity in the animal. Within forty-eight hours after one of the sacs is placed under the skin, an exudate composed almost entirely of polynuclear cells forms. In four to eight days the sac becomes almost entirely encapsulated by connective tissue. No cells can penetrate into, nor microscopically demonstrable bacilli escape from, the sac, which remains intact in the centre. The small vaccinating nucleus is then practically equal to a tubercle which is totally isolated as far as the bacilli are concerned. After six to eight months, the vaccinating nucleus calcifies and atrophies *in toto*. The bacilli degenerate, die, and decompose, so that if, after twelve to eighteen months, the whole contents of a vaccinating tubercle is injected into a guinea-pig, tuberculosis does not result.

"That a hermetically closed sac acts as a diffusion membrane for the specific bacterial products, and, on the other hand, does not allow escape of the bacteria, owing to bursting for instance, can easily be demonstrated. The sacs may be found absolutely intact when taken out of the vaccinating nucleus of an animal slaughtered one to four weeks after vaccination [specimens shown], and the emulsion layer surrounding the sac will be found non-infective. The further fate of the sac as dialyser depends generally on the quality of the bacilli, but especially on the digestion and immunising power of the vaccinating organism. I am not yet fully acquainted with the details of these processes.

"Just as the sac which is vaccinated and suspended in a flask impregnates the surrounding bouillon with specific bacterial products, it can also impregnate the body of the vaccinated animal.[1] Three to six weeks after vaccination, a non-tubercular bovine reacts characteristically to tuberculin, as Moussu has observed with porcelain filters, behaving in an analogous manner to a tubercular animal—the general effect of the vaccinating tubercle is the same as the infection tubercle.

"This tuberculin super-sensitiveness disappears, on the average, six to eight months after the vaccination, so that healthy vaccinated animals which do not react with tuberculin eight to twelve months

1. Without producing an infection, the bacteria drawing at the same time material for their sustenance through the membrane. (See Heymans' discussion on Pearson's paper, 6th I. C. on T., Vol. 4, pt. 2, p. 1003.)

later can be considered as free from tuberculosis. The vaccination is performed in the following manner :—

" A stable is entered and all animals in the herd are tuberculin tested. After the tuberculin test all the animals of the herd are vaccinated. There are numerous places where we have employed this method for the last four years, the tuberculinisation with the vaccination, and it has given entirely satisfactory results. At six o'clock in the evening the animals are tuberculinised and temperatures are taken. Next morning at six, nine, and twelve o'clock the temperatures are taken, and between nine and twelve the vaccination is accomplished ; no time is, therefore, wasted.

" The solution of the question of the changes which occur in the organism concomitant with the occurrence, existence, and disappearance of the tuberculin super-sensitiveness, during the immunisation process, demands a knowledge of the mechanism of vaccination. Before taking it up we should first agree that anti-tuberculosis vaccination is a reality.

" Is a sac-bearing animal, vaccinated against experimental reaction, also vaccinated against spontaneous infection ? Having already granted a certain immunity and healing power towards spontaneous tuberculosis, we hardly need to add that it is only relative as to intensity and duration.

" That the animals vaccinated by means of the sac are, as a result of infection, either subcutaneous or by ingestion, less susceptible, or contract a milder form of the disease, than control animals not vaccinated, appears from three series of experiments on thirty-six animals shortly summarised ; the following are the chief results :—

" Control animals succumb to the infection, but vaccinated animals do not. The latter react later to tuberculin, and show on *post-mortem* only lesions confined to small areas. The belief that this increased resistance of the vaccinated against experimental infection is proof of resistance to natural infection is supported by various series of practical experiences.

" Ten non-reacting animals, of which five were vaccinated, were brought directly into a diseased stable. Slaughtered five months afterwards with following results :—

Of the five vaccinated animals		Five not vaccinated animals	
Tuberculous	Non-tuberculous	Tuberculous	Non-tuberculous
1	4	4	1

"Of eighteen other sound animals, nine were vaccinated.

Nine vaccinated animals			Nine animals not vaccinated	
Tuberculous	Non-tuberculous	Doubtful	Tuberculous	Non-tuberculous
2	6	1	6	3

"In Belgium up to this date one thousand herds have been vaccinated, with about 40,000 animals. All animals are vaccinated whether tuberculous, pregnant, or those which have just given birth. There are absolutely no ill effects noticed from the vaccination, except occasionally the formation of a localised abscess is noticed which is the result of a mixed infection at the place of inoculation. However, they heal readily. The vaccination takes one minute. The record shows that in twenty herds in one day 400 animals were vaccinated, showing the simplicity of the technique of the vaccination.

"Among over 4,000 sound animals vaccinated during 1905, 1906, and 1907, the re-tuberculinisations have shown that the majority of them (about 80 per cent.) do not react, that they, therefore, remain free from tuberculosis—if we can rely on the tuberculin reaction of vaccinated animals. The careful *post-mortem* examination of these animals alone can decide. Among 500 examined *post-mortem* up till now [1908] are about 150 healthy vaccinated animals which did not react at the re-tuberculinisation. Tuberculous lesions have been found in about six individuals. When, therefore, the tuberculin injection is made about a year after the vaccination it is just as conclusive in diagnosis with vaccinated as with non-vaccinated animals. From the results of these numerous experiments and observations, I feel justified in concluding that animals vaccinated by means of the sac method are distinctly more resistant against artificial and spontaneous infections.

"It is desirable to raise such animals as will resist infection. Not only do I vaccinate non-reacting animals, but also those that react, believing that the vaccination is not only preventive but also curative.

"With the latter as well as with the former, the bacilli enclosed in the sac slowly but continuously allow the diffusion of tuberculin substances in the tuberculous organisms without ever causing the slightest general reaction.

"The sac method represents the most ideal injection method of tuberculin as a curative means against tuberculosis.

"In fighting bovine tuberculosis the ultimate healing or bettering of tuberculous animals is of second-hand importance, but it decreases contagion among the cattle herds. Up till now, I am able to maintain that among tuberculous animals, vaccinated individuals show a greater decrease in the number of reactors than the non-vaccinated animals, and that the former show retrogressive lesions in a considerable degree on *post-mortem*.

"As the results already published have shown, it is possible to restrict the infection of the sound animals in the diseased cattle herds. For a rational and practical fighting of the disease, one must, of course, as far as possible employ prophylactic and hygienic measures, such as isolation and slaughtering of animals with open tuberculosis, sterilising of milk, etc., in order to prevent the introduction of the disease into the very young stock before vaccination could have taken place. All animals affected with tuberculosis of the udder should, therefore, be slaughtered. The recommendations made by Professor Bang in connection with prophylaxis should be carefully executed.

"For determining the duration of the immunity, vaccinations have been repeated in a number of herds about every half year, but in most only every year, the newcomers being vaccinated first. Experiments regarding vaccination every two years, or at longer periods, are not yet concluded, but already it seems clear that a yearly vaccination of the cattle herd is more than sufficient.

"This may be proved, since the bacilli in the sac are still alive after ten to twelve months, which was established by test inoculations on guinea-pigs, and, therefore, the immunity will last at least during the time living tubercle bacilli are present.

"If by this method a relative immunity can be established, a step farther will have been reached toward the eradication of tuberculosis in animals, and perhaps, in the future, also in human beings."

Although the British Royal Commission[1] did not seriously include investigations on artificial immunity within the scope of their work, nevertheless some tentative experiments were made. These experiments showed "....that by the inoculation of large doses of human tubercle bacilli, as also by vaccination with small doses of living bovine tubercle bacilli, the calf can in many instances be enabled to resist the inoculation at a later period of a dose of bovine tubercle bacilli which otherwise would have set up in it severe and fatal tuberculosis. None of the....vaccinated animals was allowed to live for a longer period after the resistance-test inoculation than three months, and though in all of them some disease was found on *post-mortem* examination, in the great majority it was of a slight and non-progressive character.

"In certain of the animals, however, resistance in this sense was not produced, calves that had been vaccinated once and even twice with slightly virulent tubercle bacilli developed, some of them, severe tuberculosis when inoculated with virulent bovine bacilli."

The necessarily limited scope of the experiments did not permit of the Commissioners giving an opinion as to the probable duration of any resistance that might have been produced in the protected animals.

1. Memorandum to Final Rept., p. 46.

SERUM DIAGNOSIS OF TUBERCULOSIS.

The foregoing tests for the detection of tuberculosis in animals are all based on the introduction of tuberculin into the animal in one way or another, the only essential difference between the various methods consisting in the severity of the treatment. Considering the changes which occur in the blood stream following on an invasion by pathogenic bacteria, it is not surprising that biological chemists have sought to detect disease by processes of blood testing. These methods have the advantage that no test substance whatever is introduced into the animal. Although the assurances of the harmlessness of tuberculin are so conclusive, there are probably some cattle owners who would prefer a teaspoonful of blood were taken from an animal rather than have the same quantity of tuberculin put in. Unfortunately, the processes of detection are far more difficult and tedious than the tests in the animal body, hence more expensive to perform.

Disease recognisable in the blood

For those to whom expense is no objection we shall briefly touch upon the principal laboratory methods of diagnosis of tuberculosis.

Agglutination.—We have already explained (see Section III.) that the invasion of pathogenic bacteria into the blood of an animal results in a reaction of the blood in producing various principles destructive to the bacteria. Some of these substances have the peculiar power of retarding the motion of the organisms (if they be motile) and causing them to congregate, clump, or collect together. This may readily be seen in glass vessels (*in vitro*) when the bacilli sink to the bottom in a more or less felted mass or precipitate. Under the microscope the organisms are seen to collect into groups, and if motile become sluggish in their movements.

In the case of the *Bacillus Tuberculosis*, Professor Paul Courmont,[1] of the University of Lyons, states that " It is known that the usual culture of the bacillus of Koch cannot be utilised for agglutination." It was M. Arloing[2] who, in 1898, having obtained a fluid homogeneous culture of the bacillus of Koch and its agglutination by the serum[3] of tuberculous human beings or animals, created thus the sero-diagnosis of tuberculosis. Messrs. Arloing and Paul Courmont then perfected the method, determined the best manner of cultivating the homogeneous cultures, applied the sero-diagnosis to hundreds of patients, and studied on these, and on animals rendered tuberculous, the agglutinating power of the blood.

" The serum diagnosis of tuberculosis is actually one of the most employed and most certain laboratory methods of diagnosis in tuberculosis. It is practised like that of typhoid fever, by mixing the serum

1 6th I. C. on T., Vol. 1, pt. 1, p. 528.
2. Comptes Rendus Acad. des Sciences, Paris, May 9th, 1898.
3. When blood is allowed to stand at rest, a clot containing the red corpuscles and fibrin settles, leaving a clear, pale yellowish upper layer. This is serum.

of the patient with a certain quantity of liquid homogeneous culture of the bacillus of tuberculosis."

[1]" In cows, one can have statistics in which the autopsies control the serum reaction. Under these conditions M. Arloing has seen that the sero-diagnosis is always negative when the cow is non-tuberculous, and positive 98 per cent. when there are tuberculous lesions."

Advantages of sero-diagnosis

In addition to the absolute harmlessness and facility of application, Courmont[2] claims the advantage that one can repeat the test as often as one likes, and so not only detect, but prognosticate, the course of the disease (prognosis). Moreover, it can be employed to determine the location of a lesion (local sero-diagnosis), as in pleuritic fluid, ascites, and hydrarthroses.

Von Ruck[3] tells us that " It was not long after Arloing and Courmont's first publication before the diagnostic significance which they claimed for the sero-agglutination of tubercle bacilli was disputed by other observers, because it was found that not only was the reaction inconstant in tuberculosis, but that it occurred occasionally in other affections, notably typhoid fever, and with the serum of healthy individuals."

Von Ruck quotes the investigations of many eminent observers who reject the value of the test.

Courmont,[4] however, maintains that the said investigators have not avoided certain sources of error which he specifies. Mainly the sources of error lie in not using a favourable bacillus, such as the Bacillus A (Human Tuberculosis—Arloing), and secondly in failing to appreciate the importance of the fact that " A serum agglutination has diagnostic value for a given subject only according as it surpasses the agglutinating power of the serum of normal subjects of the same species and the same age."

Quantitative reaction

" One knows," says Courmont, " that every serum, even normal, possesses a certain natural agglutinous power ; the specificity of the agglutinating reaction is only relative—quantitative and not qualitative."

Courmont maintains his position unmoved.

Landouzy[5] says the agglutination tuberculin tests "....which are not as generally used as they should be, are beginning to make their way in human quite as much as in veterinary medicine."

Calmette[6] affirms that although the accuracy of this test was at first hotly contested, " To-day, its real value is generally admitted. For various reasons, however, principally because it requires a delicate technique, and the results are frequently difficult to interpret, it has

1. 6th I. C. on T., Vol. 1, pt. 1, p. 531.
2. 6th I. C. on T., Vol. 1, pt. 1, p. 534.
3. 6th I. C. on T., Vol. 1, pt. 2, p. 1198.
4. 6th I. C. on T., Vol. 1, pt. 1, p. 529.
5. 6th I. C. on T., Special Vol., p. 193.
6. 6th I. C. on T., Special Vol., p. 71.

not been generally adopted.....But the greatest obstacle to its general employment is that it necessitates a special type of bacilli....."

Mohler[1] considers that the value of this test, as also that of animal inoculation and biological test "....is discounted by the technique required, and impracticability."

"**Bordet-Gengou Reaction** is obtained," says Calmette,[2] "in the following manner: After procuring serum from a goat or sheep, which is hemolytic[3] for the red blood cells of the rabbit, some of the latter are washed and freed from every trace of serum by means of several successive centrifugations in physiological salt solution.[4] A number of narrow tubes are filled with variable quantities of the serum to be studied, which is supposed to be obtained from a tuberculous subject, and a fixed quantity of an emulsion of tubercle bacilli, rendered as nearly homogeneous as possible and obtained from a recent potato culture, is added to each tube, beginning with a very small dose (0·2 c.c. at the most) of fresh guinea-pig serum (containing the alexin or complement).[5] The tubes are then placed in the autoclave for two hours and shaken up from time to time for the purpose of mixing the contents. Finally there is added to each tube a drop of a 5 per cent. dilution of washed red blood-cells from a rabbit, and 0·2 c.c. of goat or sheep serum, which is hemolytic for the blood-cells of the rabbit, and has first been rendered inactive by heating half an hour at 58° C.[6] If the serum from the supposed tuberculous individual contains antibodies, the latter will fix the alexin or complement of the fresh guinea-pig serum on the tubercle bacillus, and the alexin or complement having thus been deviated, the hemolytic serum, which has been rendered inactive, becomes incapable of hemolysing red cells from the rabbit. On the other hand, if the serum of the suspected individual does not contain antibodies, no deviation of the complement of the guinea-pig serum on the tubercle bacilli takes place, and the complement remaining free in the mixture activates the hemolytic serum (to the red blood-cells of the rabbit) and hemolysis occurs in a few moments.

"It is evident that this method can give results only when the serum is obtained from an individual whose organism is still defending itself vigorously against a recent tuberculous infection by the production of antibodies. From this view point it is extremely interesting, since it shows an active battle against the infectious agent. Unfortunately, it has the disadvantage of necessitating very delicate manipulation, and of being beyond the reach of most physicians on account of the technical skill and the time required. Finally,

1. P. H. and M. H. S., Bull. 56, p. 509.
2. 6th I. C. on T., Special Vol., p. 72.
3. Possessing the power of dissolving blood cells.
4. Solution of common salt one-fifth of 1 per cent. strength.
5. See Section III.
6. 136·5° F.

what is more important, it gives absolutely negative results in patients in whom the infection is intense or threatens to run a rapid course. It appears, therefore, to have more interest as a prognostic sign than as a means of confirming a doubtful diagnosis.

Prognosis

"**Activation of Cobra Venom.**—The method of activation of cobra venom," Calmette continues, "is still so recent that it is too early to give an opinion in regard to its practical value. Nevertheless, there is reason to think that, although it is destined, like the preceding, to be only a laboratory method, it may render important service at least in the study of tuberculosis. It is based on the following principle: Certain serums, even when they have been rendered inactive by an exposure of one half-hour to 58° of temperature, possess the property of conferring upon cobra venom the power of dissolving red blood-cells (previously washed and freed from serum) of various species of animals, even when these same cells are not dissolved by the venom alone. Since the work done by the Ehrlich School (P. Kyes, H. Sachs) we know that this activating action on serums is due to lecithin, or lipoid substances analogous to lecithin. Lecithin is capable of combining with the venom to form lecithide, which is soluble in water, insoluble in ether, and capable by itself of producing hemolysis. In collaboration with my students, L. Massol, C. Guerin, and M. Breton, I discovered that the serums of animals spontaneously tuberculous or susceptible to the infection (man, beef, hog) are never capable of conferring hemolysing properties on venom when the serum is obtained from subjects who are entirely free from any tuberculous lesion. Serums obtained from tuberculous subjects, provided they are neither febrile nor cachectic, constantly activate the venom and render it hemolytic. Conversely, the serum of the horse, dog, rat, goat, sheep, and rabbit are always active, and these species take tuberculosis with great difficulty, either by natural infection or experimental inoculation."

The Opsonic Index.—"A very important branch of blood work, and one that seems destined to be of great value in the future," says Emery,[1] "has been introduced by Wright, who has demonstrated the presence in the blood of substances which he calls *opsonins*, and which have the power of acting on pathogenic bacteria and altering them so that they can be taken up and digested by leucocytes. These substances are of great importance in that they appear to be the chief agents in the production of some forms of immunity. Take, for instance, the defence of the body against staphylococci. Leucocytes have no power of taking up these organisms, and if the protection of the body were entrusted to them alone a slight staphylococcic lesion would be a very serious matter. But the blood contains a certain amount of antistaphylococcic opsonin—a greater amount in some persons and less in others—and this, by combining with the staphylococci, renders them easily attacked by the leucocytes. It

Opsonin

1. Clinical Bacteriology and Hæmatology, p. 148. London, 1908.

follows that where we can measure the amount of opsonin present we can form some estimate of the patient's resisting power against the organism in question. It is found, for instance, that the serum of patients in the early stages of staphylococcic diseases, such as pustular acne or boils, is usually very deficient in antistaphylococci opsonins, whilst when cure takes place the amount rises above normal. These opsonins are probably specific, *i.e.* each organism has its own appropriate opsonin: that for tubercle, for example, is devoid of action on staphylococci, and *vice versâ*." . . . . The test is carried out by mixing together a little of the serum to be tested with some living leucocytes and bacteria, in this case tubercle bacilli (dead organisms serve quite well). At the same time, and under the same conditions, a similar test is made with the serum of a healthy subject for comparison. The suspensions are kept at body temperature for fifteen minutes. During this time the leucocytes enclose as many of the bacteria as the amount of opsonin present admits of. The suspensions are then spread on microscope slides, dried and stained. When examined under the microscope with a magnification of about a million, [1]" The polynuclear leucocytes will be found to contain the bacteria, and it will be necessary to count the number in each of fifty leucocytes in both preparations, *i.e.* in that made with the patient's serum and in the control made with that from a healthy person (or bovine). The ratio between the two gives the *opsonic index*. For example, in one case the number of tubercle bacilli contained in fifty polynuclear leucocytes taken at random amounted to 78. In the control specimen from a healthy person the same number of polynuclears contained 172.

" The ratio 78 : 172 = 0·45 gives the opsonic index ; it shows that the patient has less than half the normal amount of opsonin, and probably, therefore, less than half the normal resisting power to the tubercle bacillus." **Opsonic index**

[2]"A low opsonic index towards a given organism, therefore, denotes either (1) an infection with that organism, or (2) a low power of resistance, so that if the patient is exposed to infection, invasion will readily take place. In such cases he should be carefully shielded from exposure, and the general health improved by fresh air, careful feeding, tonics, etc. **Interpretation**

" A high opsonic index (*i.e.* one decidedly above normal) usually indicates that the patient has had an attack of the disease caused by the organism in question, and has overcome it. Normal persons differ very little amongst themselves ; for instance, in a series of healthy persons, if the average index be taken as normal, it is unusual to find one below 0·95 or above 1·05."

From the results of recent veterinary work on opsonic indices it would appear that, in the present state of our knowledge, the test is hardly practicable for routine diagnostic work.[3]

1. Emery, Clinical Bacteriology and Hæmatology, p. 154.
2. Emery, Clinical Bacteriology and Hæmatology, p. 155.
3. See Strubell and Felber, Cen. f. Bakt. Parasiten. u. Infek., Band 54, H. 1, p. 44.

EXPLANATORY OF PLATE XXII.

FIG. 1.—Different forms of clubs in different specimens, magnified nearly one and a half million times, that is, 1,200 diameters.

- (*a*) Very small club-shaped elements.
- (*b*) A club with transverse segmentation.
- (*c*) A club with lateral daughter clubs.
- (*d*) and (*e*) Clubs with terminal offshoots resembling teleutospores.
- (*f*) A club with developing daughter clubs on the left, and on the right a mature secondary club.
- (*g*) A segmental club with lateral offshoots.
- (*h*) Two clubs undergoing calcification.

FIG. 2.—A very remarkable stellate growth comprised of nine wedge-shaped collections of clubs radiating from a mass of finely granular material. (Magnified 500 diameters.)

FIG. 3.—A rosette undergoing central calcification, and consisting in part of extremely elongated clubs resembling paraphyses. Calcareous matter is also being deposited in the club-shaped structures. (Magnified 500 diameters.)

FIG. 4.—Part of a rosette with continuation of the club-shaped bodies into transversely segmented branching cells, apparently representing short hyphæ. (Magnified 500 diameters.)

FIG. 5.—A rosette from another section in which similar appearances are observed as in Fig. 4. (Magnified 500 diameters.)

BOVINE ACTINOMYCOSIS.

APPENDIX A.

BOVINE ACTINOMYCOSIS.

ACTINOMYCOSIS, or madura disease, is a chronic inflammatory infection found in man, horses, cattle, and pigs. It closely resembles tuberculosis in the appearance of its victims and of the lesions, which are in the form of nodular tumours caused by a club-shaped microscopic fungus known as actinomyces, or ray fungus. Crookshank[1] tells us that "This disease in cattle has long been known in this country, but its various manifestations were either mistaken for other diseases or simply received popular names. Indeed, the various forms are still familiar to many as wens, clyers, or crewels; scrofulous, tubercular, or strumous abscesses; polypus, lymphoma, cancer of the tongue, scirrhous tongue, indurated tongue, ulcerated tongue, cancer of bone, bone tubercle, osteo-sarcoma, fibro-plastic degeneration of bone, spina vertosa, and carcinoma.[2]

"Bovine actinomycosis is especially prevalent in river valleys, marshes, and on land reclaimed from the sea. The disease occurs at all times of the year, but general experience leads to the belief that it occurs more commonly in winter. . . . There is little, if any, evidence to show that the disease is hereditary. The tongue is so commonly the seat of the disease that suspicion at once falls on food as the means by

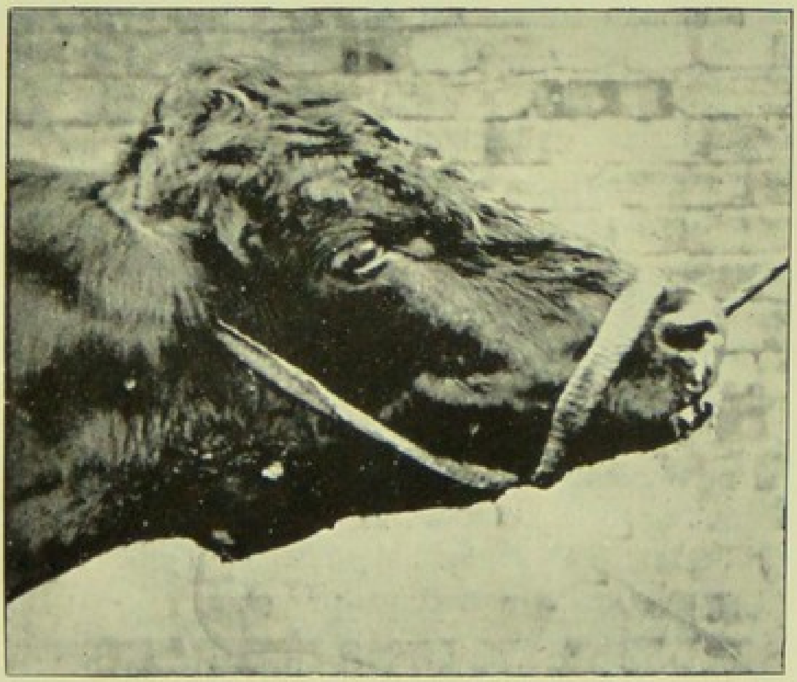


FIG. 13.—From a photograph of a Norfolk steer. There is a growth about the size of an orange in front of the throat, an example of a so-called "scrofulous" or "strumous" tumour. This growth was associated with a large polypoid growth in the pharynx which, by interference with deglutition, produced emaciation (Fig. 14).

1. Bacteriology and Infective Diseases, 1896, p. 414.
2. We may add wooden tongue and lumpy jaw.

which the parasite is conveyed. Skin wounds produced by rubbing against the mangers, posts, or wire fencing may also become infected.

"Jensen believed that the disease was produced by different kinds of grain, especially when cultivated on ground reclaimed from the sea.....According to Jensen, the fungus grows on grain, husks, and straw of different cereals, but most abundantly on barley, which is also the most likely to wound the mucous membrane. Johne's observations tend to corroborate this view, for in twenty-two out of twenty-four cases in which he found barley sticking in the tonsils of pigs, he found the beard thickly beset with a fungus very similar to, if not identical with, the ray fungus."

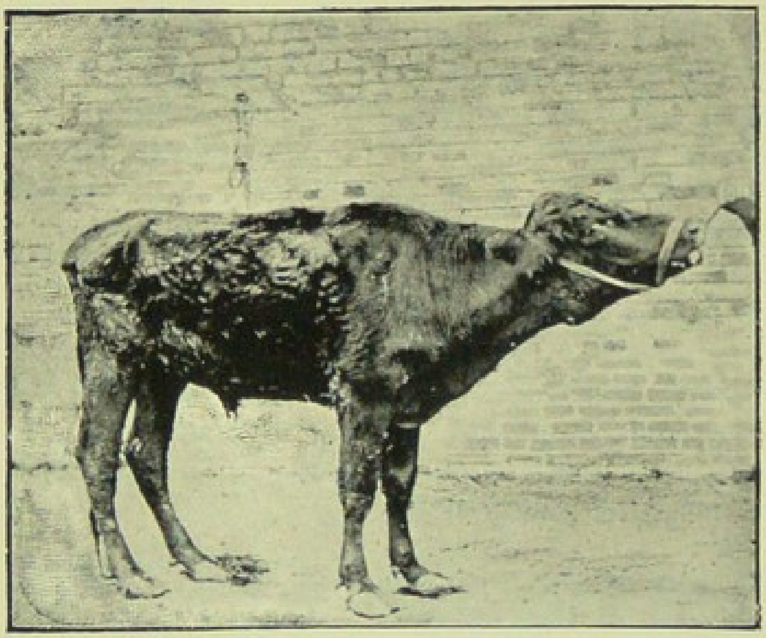


FIG. 14.—Photograph of a steer nearly three years old, but about the size of a yearling. The emaciation and deplorable aspect recall the appearance of a "piner" or "waster" (tuberculosis).

The great difference between the parasites of tuberculosis and actinomycosis renders the distinction easy for the pathologist, but practical veterinarians and breeders of cattle are liable to mistake some manifestations of actinomycosis for tuberculosis. Extreme emaciation may result in actinomycosis, producing a condition which, without a *post-mortem* examination would probably be attributed to tuberculosis, the animal being regarded as a "piner" or "waster." "There is no evidence to show that the flesh of animals suffering from actinomycotic tumours is unfit for human consumption. In very severe cases it is unwholesome, but there is no evidence that it can produce actinomycosis in man."

The figures shown in Plate XXII (facing p. 408) were taken by Professor Crookshank from sections of a case of so-called "osteo-sarcoma" in which the growth of the fungus was remarkably luxuriant. The colours shown are, of course, dyes with which the sections had been stained to reveal the structure.

Plate XXII and Figs. 13 and 14 are reproduced from Bacteriology and Infective Diseases, by kind permission of Professor Crookshank.

APPENDIX B.

JOHNE'S[1] DISEASE.

PROFESSOR Sir John M'Fadyean[2] gives the following account of the recognition of this disease: "In the year 1895 Johne and Frothingham described a remarkable case of enteritis[3] in a cow in which the intestinal mucous membrane contained large numbers of an acid-fast bacillus, thought to be perhaps the bacillus of avian tuberculosis. This observation did not immediately receive the attention which it deserved, and apparently no similar case was recorded until Markus called fresh attention to the disease, and pointed out that it was not of rare occurrence in Holland. Since that date the same disease has been recognised in Belgium by Liénaux and van den Eeckhout, in Switzerland by Borgeaud, and in Denmark by Bang."

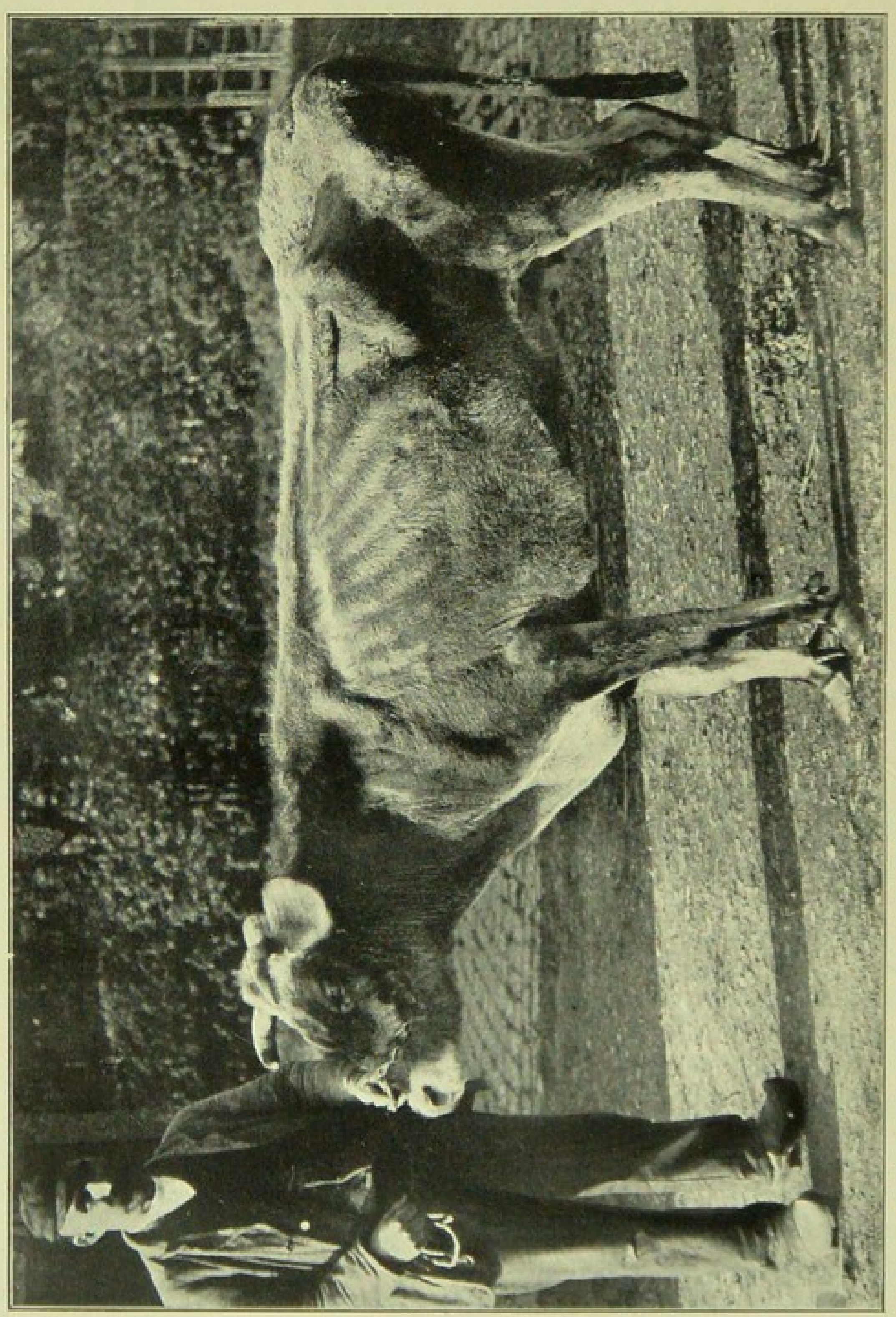
M'Fadyean calls attention to the fact that the disease is also comparatively common in Great Britain. During the year preceding the writing of his article, the professor had diagnosed nine cases from eight different farms in various parts of England. Detailed notes of these cases are stated.

"It can hardly be doubted," says M'Fadyean, "that the bacillus which is so abundantly present in the intestinal mucous membrane, and also, as a rule, in the mesenteric and colic lymphatic glands, is the cause of the disease, though the strict proof of this has not yet been led." In appearance the organism closely resembles the tubercle bacillus, though it is, perhaps, a little shorter, and is remarkably acid fast. It is now known that the organism is quite distinct from that of avian tuberculosis and also from that of mammalian tubercle bacilli. M'Fadyean showed that when the bacilli causing this chronic enteritis were inoculated into guinea-pigs and rabbits the animals did not contract the disease. Again, all attempts to cultivate the organism artificially in the laboratory have failed. "Mainly on account of the acid-fast character of the bacilli, the disease has been referred to as a pseudo-tuberculosis, and Bang has suggested that it should be called 'chronic bovine pseudo-tuberculous enteritis.' The first objection to this term," says M'Fadyean, "is that it is too cumbrous for general use, and the second is that it would be almost certain to perpetuate the idea that there is some natural connection between this disease and tuberculosis."

1. To arrive at the correct pronunciation of this name, first say "Yohner," then repeat it omitting the "r."
2. Jour. of Comp. Path. and Ther., Mar., 1907, p. 48.
3. "Enteritis"—inflammation of the intestines, especially of the small intestine.

We are indebted to Professor Bang for loan of blocks in this appendix on Johne's Disease.

PLATE XXIII.



A YOUNG JERSEY "PINER" SUFFERING FROM JOHNE'S DISEASE.

This latter objection also applies to the term "para-tuberculosis," which Ostertag[1] informs us is employed on the Continent. M'Fadyean, therefore, suggested the term "Johne's Disease." The proposal has been adopted, in this country at least.

The disease is essentially an inflammation of the intestines (enteritis) affecting primarily the small intestine, but, as a rule, involving the large intestine also before death takes place. "Apparently," says M'Fadyean, "a variable length at the beginning of the small intestine generally escapes, and the last part of the ilium is usually the worst affected. No doubt the disease begins in the mucous membrane, and even in animals seriously ill this may be the only part of the bowel affected. In the worst cases, however, the bacilli have also invaded the submucous coat, and the bowel wall is then quite distinctly thicker than normal. In proportion to the degree of this thickening, the surface of the mucous membrane shows more or less coarse wrinkling, which is usually most pronounced in the terminal part of the small intestine. When a fresh normal bowel is laid open the mucous membrane becomes thrown into folds or wrinkles, but gentle traction suffices to obliterate these. Here, on the other hand, the folds are of a permanent character and are much coarser in appearance." In none of the cases that M'Fadyean had observed up to 1907 was there any ulceration of the mucous membrane, and in most of them there was but little congestion. Critical examination of the mesenteric lymphatic glands shows that they are only sometimes a little enlarged. When they are divided with the knife an appreciable amount of a watery liquid exudes from the cut surface. There is no congestion in the glands, and the tissue appears quite normal to the eye.

The absence of tubercles and, in fact, the trivial character of the lesions, even when enormous numbers of bacilli are present, sharply differentiate this disease from tuberculosis.

The histological alterations in the tissue are minutely described by M'Fadyean. The absence of necrosis or caseation is explained on the basis that the organism does not form any powerful cell poison. The tissue cells appear almost powerless to restrain the multiplication or dissemination of the bacilli, hence the lesions are progressive and diffuse. The wall of the intestine is the most favourable seat with the lymphatic glands attached to the intestines as the limit. No doubt the bacilli must sometimes be carried into the lungs and other organs, but apparently the conditions for growth are here unfavourable.

"*Symptoms.*—The earliest symptom of Johne's Disease is loss of condition, in spite of a normal appetite and a sufficiency of food. The animal's coat takes on an unthrifty appearance, and diarrhœa soon sets in. As a rule, when once the diarrhœa has begun, it is profuse and persistent, though it may sometimes be temporarily

1. Private communication.

checked by feeding on dry food and the administration of astringents. When the disease is allowed to run its natural course, the animal generally continues to feed and ruminate until the last day or two of life, and death appears to be the result of the exhausting diarrhœa. It is possible that there are mild non-fatal attacks of the disease, but recovery appears never to take place when once the disease has become fairly established, as indicated by marked loss of condition and diarrhœa. Some cases prove fatal within a few weeks after the onset of symptoms, but when the animals are housed and liberally fed, death can generally be staved off for several months."

M'Fadyean described one case in which a cow had been ill for nearly a year before it was killed.

"The symptoms of Johne's Disease," M'Fadyean continues, "agree exactly with those which have been ascribed to parasitic gastritis in cattle, and it appears to be very probable that, in recent years, a chronic diarrhœa in cattle has sometimes been too hastily ascribed to the presence of worms in the fourth stomach. At any rate, in future it will be necessary in all such cases to devote attention to the intestine, and to search there for evidence of Johne's Disease.

"*Mode of Infection, etc.*—Johne's Disease must be regarded as one which results from infection and from infection only. In all those cases which have come under my observation," says M'Fadyean, "there was a history of similar cases on the same farm, in several instances extending back over a period of many years. The fact that it has proved impossible to cultivate the bacillus in artificial media may be taken as very strong evidence that it is incapable of multiplying external to the body[1]—in soil, water, or fæces. One may, therefore, assume that the disease is never sporadic, and that when a case of it occurs there must have been direct or indirect connection with an antecedent case. In harmony with this view, one finds that the nature of the soil appears to have no bearing on the prevalence of the disease.

"During the advanced stages of the disease large numbers of the bacilli must be voided with the fæces, and in all ordinary circumstances there are ample opportunities for infection from this source. In this way both pasture and other food materials, as well as drinking water, may become seriously contaminated. At the present moment (1907) there is no knowledge with regard to the resistance of the bacilli outside the body, or the length of time for which a contaminated pasture may be dangerous.

"*Prevention.*—In the present state of knowledge this is a matter of extreme difficulty in the case of farms on which the disease has existed for a number of years. Clearly the most rigid isolation of diseased and suspected animals ought to be practised. Indeed, at present, and until some efficient method of treatment is discovered,

1. In other words, it is an obligate parasite.

it would appear to be best to destroy diseased animals as soon as a positive diagnosis can be made. The fæces passed by diseased or suspected animals ought to be destroyed. It is obvious, however, that these measures cannot be expected to prove immediately effective, for it is almost certain that infected animals may distribute the bacilli with their fæces for some considerable time before they show any indications of illness. The discovery of a means of cultivating the bacillus artificially might lead to the preparation of a diagnostic agent analogous to tuberculin which would be of great service in this connection.

"The question whether the disease ought to be scheduled so as to bring it under the provisions of the Contagious Diseases of Animals Acts deserves serious consideration."

Mr. James T. Angwin, M.R.C.V.S.,[1] describes his experience with a notable outbreak of Johne's Disease in a herd of Jersey cattle at Arundel. This veterinarian confirms the precise description of the disease as stated by M'Fadyean, and acknowledges the difficulty of diagnosing it in the living animal. He relies, however, mainly on negative indications. Thus, in the presence of persistent diarrhœa, having excluded tuberculosis by means of the tuberculin test, also verminous enteritis or gastritis, he inquires into the history to find if the affected animals came from a herd subject to diarrhœa.

Angwin states that considerable differences are noted in the loss of condition of different animals, some losing flesh very rapidly, others retaining a very fair condition and healthy appearance for a long time until the later stages of the disease.

The severity and duration of the diarrhœa also varies, the cows on grass, and especially on swampy land, showing the most profuse discharge. In one case described by Angwin the diarrhœa lasted eighteen months, and on *post-mortem* only slight changes were visible, while in another case a young cow calved, pined, scoured, and died in six weeks.

The temperature of the animals is not very high, being usually 100 to 100·8. Systemic changes, notably calving, bring about collapse. In suspicious cases, use the thermometer freely. "Where there is one cow affected there are almost sure to be others, so carefully observe the herd when tied up at milking time and notice the nature of the fæces."

"The only treatment I can advise," says Angwin, "is the use of sedative medicines given in plenty of wheat flour and starch gruel; when necessary, stimulants may be added, and animals should be kept on a dry nutritive diet."

In the case of the Arundel herd, Angwin states, "Since I destroyed all the animals of this herd suffering from the disease and isolated any suspected cases, the apparently sound cows were put on fresh pastures and the contaminated meadows were thoroughly dressed

1. The Veterinary Record, July 20th, 1907, p. 36.

with lime[1] and allowed to remain empty for nearly three months. The cows have now returned to these meadows, and I have had no further trouble, and none of them have showed any symptoms of scouring."

In making a *post-mortem* examination of an animal, Angwin recommends that the whole of the small and large intestine, with the mesentery and its lymphatic glands, be carefully removed and placed on a tray or table where they can be conveniently examined. The whole of the bowel should be split open its entire length (this, although it may sound a long undertaking, is easily done with a pair of bowel scissors or a sharp, thin-bladed knife with a cork fixed on the point), for the mucous membrane varies considerably, one portion being often more affected than another. The small intestine is the part usually most affected, although the whole of the bowel, both large and small, is often very much thickened in advanced cases of the disease.

The final and conclusive identification of the disease is, of course, the finding of the bacillus. To effect this, take a portion of the diseased bowel, wash it carefully to remove traces of fæces, make a smear or scraping of the mucous membrane on an ordinary glass slide or cover glass, fix and stain by Ziehl-Nielsen's method. Methylene blue may be used as the contrast stain. Wash, dry, and mount. On microscopic examination the organism will then be found stained red, the remaining parts blue.

Angwin[2] doubts whether Johne's Disease and tuberculosis have ever been discovered together in the one animal. He has never found them, and inclines to the belief that in some way at present not understood they are incompatible.

Johne's Disease has not been observed in sheep or goats, and deer are said to be immune. He has gathered from Professor Sir John M'Fadyean that the disease is rampant in Jersey.[3] This fact would seem significant when one remembers that Jersey is free from bovine tuberculosis.

C. W. Townsend, F.R.C.V.S.,[4] has reason to believe that Johne's Disease is especially prevalent in the Fen districts of this country. He has met with it in practically all breeds of cattle, and believes that all are equally susceptible to the disease. It does not appear to spread very rapidly, but, Townsend continues, most commonly occurs in isolated cases, affecting single cattle over two years old—seldom younger cattle. "Again, the cough which is seldom absent in advanced cases of tuberculosis is never a symptom of this disease."

1. The veterinary adviser of The Field has more recently mentioned salt for this purpose (see The Field, Aug. 5th, 1911, p. 317).
2. Private communication.
3. According to "Pateley Bridge," Professor Wooldridge confirms this (see Farm and Home, Aug. 27th, 1910, p. 621).
4. The Veterinary Record, June 26th, 1909, p. 870.

Townsend says that the disease "....has been stated to occur in deer," but is not readily transmissible to cattle experimentally by the ordinary methods of infection. He has not found any animals suffering with it react to tuberculin.

Microscopically one finds the bacteria are arranged in faggots or bundles, but Townsend does not find these easily discovered in the fæces of the living animal.

"In my opinion," this authority concludes, "the safest and most rational course to adopt, when once diagnosed, is immediate slaughter. Attention may then be turned to methods which will prevent its further spread.

"It is needless for me to say that all buildings and premises in which the infected animals have been housed should be thoroughly disinfected, and if possible kept free from cattle for some considerable time. Manure where such animals have been should be put upon arable land and ploughed in, or, better still, if possible destroyed."

Townsend agrees that the disease ought to be scheduled among the infectious diseases of animals.

The veterinary adviser of The Field[1] says that "The Board of Agriculture has the subject under consideration."

The belief in the immunity of deer to Johne's Disease is negatived by Professor Sir John M'Fadyean's[2] record that he has found the disease in a deer which was sent to him from a park in which several animals suffered from chronic diarrhœa.

Concerning sheep, Professor Bang[3] tells us he has been informed by Veterinary Physician Vukovic, Livno in Bosnia, that he has found the disease in these animals. Professor Bang is now endeavouring to produce the disease experimentally in sheep.

The disease is, therefore, not peculiar to cattle, neither is it confined to mature cattle. Oluf Bang[4] admits that young animals are far less subject to the disease than older animals, just as one finds in the case of tuberculosis.

He cites the case of a large estate on which one-third of the milking cows were affected in some degree. Among fifty-eight young cattle of this herd only four were affected.

Professor Bang[5] states that animals of one and a half to five years of age are specially attacked, and although young cows are the most frequent sufferers, male animals, calves, and heifers are also attacked.[6] This investigator produced the disease experimentally in calves.[7]

We are unable to follow Mr. Angwin's theory of incompatibility

1. The Field, Aug. 5th, 1911, p. 317.
2. Jour. R. A. S. E., 1907, p. 205.
3. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 40 footnote.
4. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 46.
5. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 28 footnote.
6. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 23.
7. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 34.

of tubercular disease and Johne's Disease, seeing that the co-existence of the infections in material used in experiments constituted one of the difficulties in distinguishing the diseases. This was apparently the case in Liénaux and van den Eeckhout's[1] work. In his attempts to communicate Johne's Disease to experimental animals by inoculation of infected material, Bongert[2] also found that the majority of the animals became tuberculous, although after a considerable length of time. From this evidence Bongert concluded that the disease was caused by attenuated tubercle bacilli.

In his paper of 1907 Professor Sir John M'Fadyean[3] describes the case of a cow which suffered from Johne's Disease and tuberculosis at the same time. In one series of experiments Bang[4] inoculated sixty-four guinea-pigs with parts of intestines of cows suffering from Johne's Disease. He regarded it as fortunate that only five of the guinea-pigs became tuberculous, and these, he says, "....were all inoculated with part of the intestines of cows which were suffering from tuberculosis coincident with Johne's Disease." The cows came from a district in which tuberculosis was rare.

In the details of one of these cases it is stated[5] the affected cow, in addition to Johne's Disease, was suffering from genuine tuberculosis in a mesenteric gland and a gland of the thoracic cavity. In another series fourteen cows suffering from Johne's Disease were experimented with. Two of them transmitted tuberculosis to guinea-pigs.[6]

We shall now proceed to an abstract of the masterly report by Professor Bang, issued from the Danish Royal Veterinary and Agricultural High School, 66th Report, 1910, in which a thorough history of the disease is given for the first time in Danish. We shall only treat those portions of the report which afford additional or new information on the description of the disease already given.

It is interesting to find the veterinarians recalling instances of the disease which puzzled them in their earlier days.

Professor Zschokke, of Zurich, expressed the belief that the disease which the farmers called "cold, feverless, fiery thirst" was caused by the small round worm Strongylus in the stomach and intestines. On his suggestion a young veterinarian, O. Schnyder, investigated the disease, and in 1906 published a dissertation describing an extraordinary number of different kinds of the above-mentioned worms found in the affected animals. Bang, however, expressed the opinion that the disease was not caused by the worms alone, but was

1. Annales de médecine vétérinaire, 1905; quoted by Bang, 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 9.
2. Quoted by Bang, 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 13.
3. Jour. Comp. Path. and Ther., Mar., 1907, p. 51.
4. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 10.
5. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 33.
6. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 30.

also connected with bacillary disease of the intestines. This view, as we have seen, proved to be correct.

Dr. Leonard Pearson[1] tells how in America the disease at first was thought to be tuberculosis, and when this was disproved the blame was shifted on to the feeding stuffs.

Occurrence.—Bang quotes records showing the existence of the disease in the greater part of Europe, in America and South Africa, and concludes that it is found in the most different breeds all the world over. Sporadic occurrence with isolated cases in otherwise sound stocks are certainly known, but it is very often enzootic in its appearance and recurs in certain stocks year after year, often with many cases. Mostly cows are attacked, but, as already stated, the males do not escape.

Prevalence.—P. H. Nielsen, an eminent veterinary practitioner of Denmark, informed Bang that the disease had occurred on three country estates within his practice. On one the losses were not very large, on the second about eight animals were lost yearly, and on the third the losses rose to sixteen out of a stock of 250 animals. The owner stated that the disease had only been known on this estate for about nine years.

"The losses caused by the disease," Bang[2] continues, "are sometimes considerable. On one of the farms in Lolland....10 per cent. of the cows died in one year from the disease. In the following years the losses diminished somewhat, but in the next four years, out of a stock of 250 milch cows, eighteen were lost or had to be slaughtered when very ill.....In some Jersey stocks the losses were still higher. One stock lost in one year about twenty animals of a total of 175; another, during two years, about thirty out of 250, and I doubt," Bang continues, "whether there are any large Jersey stocks in Denmark in which the disease has not caused larger or smaller losses."

Bugge and Cordsen[3] relate the experiences on a farm in Sleswig with 120 milch cows, three steers, and a large number of calves and young cattle. The disease had occurred since 1891. During the succeeding fifteen years more than 110 animals are believed to have died or have been slaughtered on account of the disease. Of the animals born in 1891 none survived more than four years.

In a circular from the Kustos Cattle Insurance it is stated that amongst the forty stocks of Jersey cattle insured by them for about one million Kroner the disease claimed 150 victims in twenty-nine herds, requiring a compensation of about 28,000 Kroner, while the compensation for about twenty stocks of native breeds only

1. Quoted by Bang, 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 14.
2. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 27.
3. Zeit. für Infektionskrankheiten, V., p. 133; quoted by Bang, 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 28 footnote.

amounted to about 6,000 Kroner. These authorities add, there is, therefore, no doubt that Jersey cattle suffer more from this disease than Danish cattle.

Fortunately, a method of diagnosis so eagerly hoped for by our British veterinarians has been found by the younger Bang. He discovered that animals suffering from Johne's Disease react to avian tuberculin, which he finds to be a specific. We shall return to this important aspect of the question later (see p. 429), but in the present connection may mention that he has found from 6 to 35 per cent. of mature animals of affected stocks react.

Conditions favouring Development of the Disease.

Although M'Fadyean could not trace any influence between the occurrence of the disease and the condition of the soil, Bang observes that those farms in Lolland where the illness was first observed comprised low-lying moist pasture. In the opinion of Bang this question requires further investigation. The disease seems generally to be worse in winter, and it is not uncommon that improvement takes place when the cows are sent out to grass. Feeding with large quantities of frozen, dirty turnips seems to have a very unfavourable influence, and Bang inclines to the opinion that the heavy losses experienced in many Danish stocks are connected in some way with this ration.

Portal of Entry.

Bang agrees that infection is mainly conveyed by ingestion, but both he and Miessner have produced infection by inoculating mucus of affected bowels into the jugular veins of calves.

Prevalence in Jersey Cattle.

Bang states that Jerseys have largely preponderated among the affected animals he has met, and when attention was first drawn to the disease it was quite clear that it often occurred in the herds of Jersey cattle which had been imported (during the last ten years) either direct from Jersey or from Sweden, while it could not be said that in former years it had spread to any great extent. Certainly the disease existed in Denmark long before any Jersey cattle were imported, and it must not be forgotten that it can cause exceedingly heavy losses in purely Danish stock. Nevertheless, it is clear that, at any rate under Danish conditions, Jersey cattle possess less resistance to the disease than Danish cattle. In view of the frequency of the disease in Jersey this becomes intelligible.

Infectious Nature of the Disease.

Oluf Bang[1] admits that Johne's Disease does not seem to be as infectious as tuberculosis ; nevertheless, Professor Bang[2] points out that

1. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 47.
2. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 28.

the markedly insidious mode of attack constitutes a serious difficulty in guarding against the introduction of the disease. This is well shown by some of the observations of P. H. Nielsen. The disease had occurred occasionally on Farm S. for fifteen years. Two pregnant heifers were sold from this farm to Farm H., where the disease was quite unknown. In the spring of 1905 one of these heifers became ill, and in July of the same year died of Johne's Disease. The other heifer showed signs of the disease in the autumn of 1905—emaciation in spite of good appetite, but no distinct diarrhœa. After its second calf this animal died—in May, 1906.

Professor Bang examined the intestines: he found the characteristic symptoms of Johne's Disease, and entertained no doubt that both animals were affected with the disease when they left the farm of their birth, although they showed no signs of the disease until one and one and a half years later respectively. During the summer of 1906, over two years after the heifers had come to Farm H., a nine-year-old cow which had been bred on the farm contracted diarrhœa and lost flesh; it died in August of the same year, and showed the typical inflammation in the small intestine on *post-mortem* examination. Mr. Nielsen was accurately acquainted with the condition of health of the stock, as he had conducted *post-mortem* examinations on all stock which had died on this farm during fifteen years (with the exception of young calves). It is, therefore, quite out of the question, Bang states, that any case of Johne's Disease could have escaped Nielsen's notice. Bang is confident that the circumstances unmistakably prove that two infected but apparently sound heifers had transmitted the disease from Farm S. to Farm H., and after a long time had infected a cow of the original stock of Farm H.

Another case observed by Nielsen shows a still slower development of the disease. A calf was bought from above-mentioned Farm S. and transferred to Farm U., where the disease was hitherto unknown. In 1905, when this calf had become a three-year-old cow, Nielsen observed that it was ill, and diagnosed Johne's Disease. About three and a half months later the cow died, and the diagnosis was confirmed by *post-mortem* examination.

A calf born on January 31st, 1902, on Farm S.G., where the disease had existed for several years, was sold on March 31st, 1902, to Farm H.G., where the disease was unknown. In September, 1907, this animal died of Johne's Disease. Bang admits that when one is dealing with a disease of such extremely insidious nature it will often be difficult or impossible to trace the manner of its introduction into a stock.

Symptoms.—Diminution in the yield of milk, and failure to thrive in proportion to the food eaten, are regarded by Bang as the first observable symptoms. As a rule, diarrhœa of varying intensity follows, the excreta containing air bubbles, usually normal in colour, occasionally containing particles of slime, and seldom a little blood.

When the diarrhœa is very intense the animal suffers very much from thirst. As already noted in one of P. H. Nielsen's cases, sometimes there is no diarrhœa.

Other Causes of Diarrhœa.—Diarrhœa may, of course, be due to several other causes, notably defects in food, cold, or presence of parasites.

Treatment.—The use of medicaments often produces apparently a temporary improvement, but considering that the course of the diarrhœa shows such variations in the absence of any treatment, and even without changes in the food, it is impossible to decide if any improvement which occurs after the use of a medicament is due to the treatment.

When one considers the characteristic, deep-seated changes caused by the disease in the mucous membrane and lymphatic glands, one could only hope to find any distinct curative action from a medicament which acted specifically on the bacilli. There seems no hope of finding such until one can at least cultivate the causal organism.

Recovery.—Bang was informed by a veterinary surgeon that he had seen a cow imported from Jersey suffer from persistent diarrhœa which defied all treatment, and within two months caused marked emaciation. When the cow was put out to grass it recovered, and two years afterwards was still apparently quite well. Again, the owner of a large herd of tuberculosis-free Jerseys informed Bang that he several times had cows which in the course of years suffered periodically from diarrhœa. They would then remain well for a couple of years or so, and finally die of Johne's Disease. One such animal, after about two and a half years' persistent illness, recovered so far as to yield a normal quantity of milk for eighteen months. Whether the recovery was permanent or no could not be ascertained, as the cow was sold.

Bang does not consider the evidence on the question of possible recovery as conclusive.

Professor Sir John M'Fadyean[1] records a case of apparent recovery. "The exceptional case," says M'Fadyean, "was a yearling which, along with a cow on the same farm, developed symptoms of the disease in the autumn of 1906. Both animals were brought to the College, and soon afterwards the cow was killed and the disease verified at the *post-mortem* examination. The yearling, although not medicinally treated, gradually ceased to scour, and gained a little in condition. It was killed six months after admission, and the *post-mortem* examination showed that the intestine was normal in appearance, while none of the characteristic bacilli could be detected with the microscope.

"The fact remains, however, that when the disease has advanced so far as to cause decided symptoms (the chief of which are diarrhœa

1. Jour. R. A. S. E., 1907, p. 205.

and wasting) the case may be considered hopeless, and the wisest course is to have the animal destroyed as a source of danger to others."

Just as one finds in testing for tuberculosis with ordinary tuberculin that animals which react to a first test do not always react to a second (see p. 235), Oluf Bang[1] finds that by his method of diagnosis for Johne's Disease, animals which at one time have given a positive result, later on yield a negative result. This investigator mentions a case of a large stock which had been tested twice with an interval of eight months between the two tests. Thirteen per cent. of the animals which had reacted to the first test failed to react to the second test. This, he considers, points to the possibility of recovery.

Post-mortem Appearances.—In some cases the changes in the intestines are so slight as easily to escape observation. This is readily understood in the case of slightly decomposed bowel, such as that sent for examination from a distance, but Bang describes cases in which the changes were only slightly visible in bowels from freshly slaughtered animals which had died from the disease. In such cases it is also difficult to find the bacilli in scrapings of the intestines. As here indicated, it is important that the intestine should be as fresh as possible.

In conformity with the marked variations of the characteristics of the disease found in some cases, one also finds great differences in the number of bacilli found. Sometimes the cells are crammed full and the nuclei obscured or displaced by them. Sometimes they form beautiful wreaths in the swollen cells. In other cases only very few bacilli lying singly are found. Occasionally, the counterstaining reveals the presence of other non-acid-fast bacilli of various types, especially in the upper part of the mucous membrane, but ordinarily only in small numbers. The organisms of Johne's Disease also stain by Gram's method and by carbol methylene blue.

The great changes often found in considerable areas of the intestines must account in some measure for the derangement of the nutrition and consequent emaciation, but the fact that great changes in this respect are sometimes accompanied by only slight alterations in the intestines indicates that disturbances mainly result from a toxic virus produced by the bacilli.

In cases of severe wasting, the little remaining fat resembles jelly. Bang has never seen any real lesions in the intestine in cases of Johne's Disease, the nearest approach to such being flat necrotic crusts on the mucous membrane, probably caused by bleeding under the surface.

The usual appearance of the bowel is shown in Figs. 15 and 16, The characteristic warty appearance of Fig. 17 is only infrequently seen. The inner surface of the small intestine is covered with

1. 66de Beretning fra den Kgl. Veterinær-og Landbohöjskoles, p. 47.

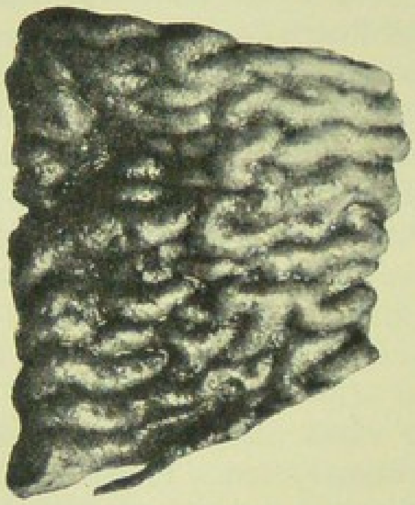


FIG. 15.—Piece of small intestine of calf suffering from Johne's Disease.

FIG. 16.—Piece of small intestine of cow suffering from Johne's Disease.

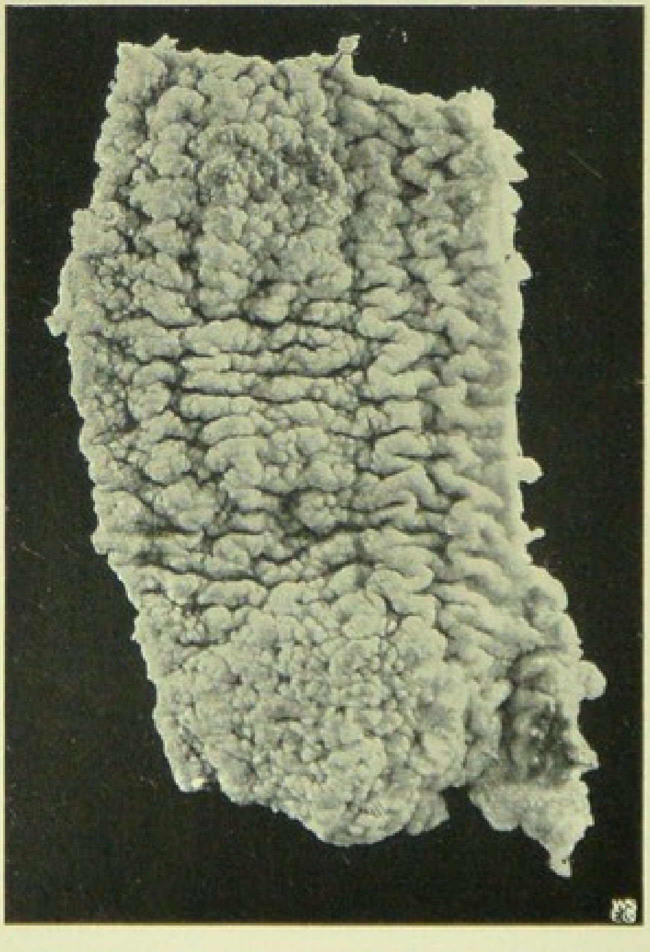


FIG. 17.—Piece of small intestine of cow suffering from Johne's Disease (showing folds and warts).

numerous fine projections known as papillæ, or villi. On cutting sections of intestine in the direction which show these prominences best (transverse section), staining, and mounting, one sees by microscopic examination the appearance shown in Fig. 18 for normal villi and Fig. 19 shows the changes caused by Johne's Disease. Note the ends of the villi shaped like ninepins or clubs. One sees also all sorts of irregular shapes, often long and thick, but usually short and thick, especially where the intestine is thick. Freshly fixed intestine shows the epithelium on the villi, but if several hours elapse before fixing the epithelium on the greater part of the villi disappears. Fig. 20 shows a villus more highly magnified and revealing epithelial cells. Fig. 21 shows another section of diseased small intestine and Fig. 22 diseased mesenteric gland.

The anæmia found in the suffering animals is partly accounted for by the diminution in hæmoglobin and red corpuscles of the blood. Such have been observed by Bang.

Detection of the Bacillus in Fæces.—Bang refers in terms of highest praise to Meyer's treatise on Johne's Disease. Meyer recommends a search for the bacilli in the fæces as a means of certain diagnosis. It is recommended to spread a thin coating of the fæces on a plate and seek out the small particles of slime or fibres which are occasionally found. These often contain the acid-fast bacilli.

Bang believes that although the total number of bacilli excreted at one time is not great, they can be conveniently detected when slime rich in bacilli is present in the fæces, but this is by no means always the case.

Bang has in many cases succeeded in detecting the bacilli in a piece of rectum pinched off with the thumb nail against the forefinger after introducing the hand into the passage. The particle is rubbed out between two slides, dried, and stained. This method will, of course, only be successful when the disease has reached so far down as the rectum. Negative results are valueless.

Attempts to cultivate the Bacillus.—At least two investigators lay claim to having cultivated the bacillus artificially. Bang considers the cases are not clear, however. He certainly has so far failed, although he has tried horse serum, cattle serum, hay infusion, potatoes (with glycerine or serum), agar (with glycerine, serum, milk, and with different degrees of alkalinity), milk, sterile lymphatic glands, and other media employed both in presence and absence of air.

Attempts to inoculate the Disease.—In 1906 Bang announced that he had succeeded in infecting calves with Johne's Disease by feeding mucus scraped off the small intestine of an infected cow. So far he has not succeeded in infecting other animals by subcutaneous, intraperitoneal, or intravenous injection, nor by feeding the bacilliferous mucus from diseased intestines, feeding mesenteric glands to a large number of guinea-pigs, to rabbits, mice, rats, fowls, and goats.

FIG. 18.—Slightly magnified section of normal small intestine. In the majority of the villi large lymphatic spaces are seen.

FIG. 19.—Slightly magnified section of small intestine of cow suffering from Johne's Disease. Heaps of large epithelial cells are seen in the villi; similar heaps are also seen lower down amongst Lieberkühn's glands.

FIG. 20.—A single villus, highly magnified, from experimentally infected calf, containing a mass of large epithelial cells. The epithelium is well preserved.

FIG. 21.—Section of small intestine of cow suffering from Johne's Disease (showing giant cells). On the villi the epithelium is partly loose. Lieberkühn's glands are shown on the left (medium magnification).

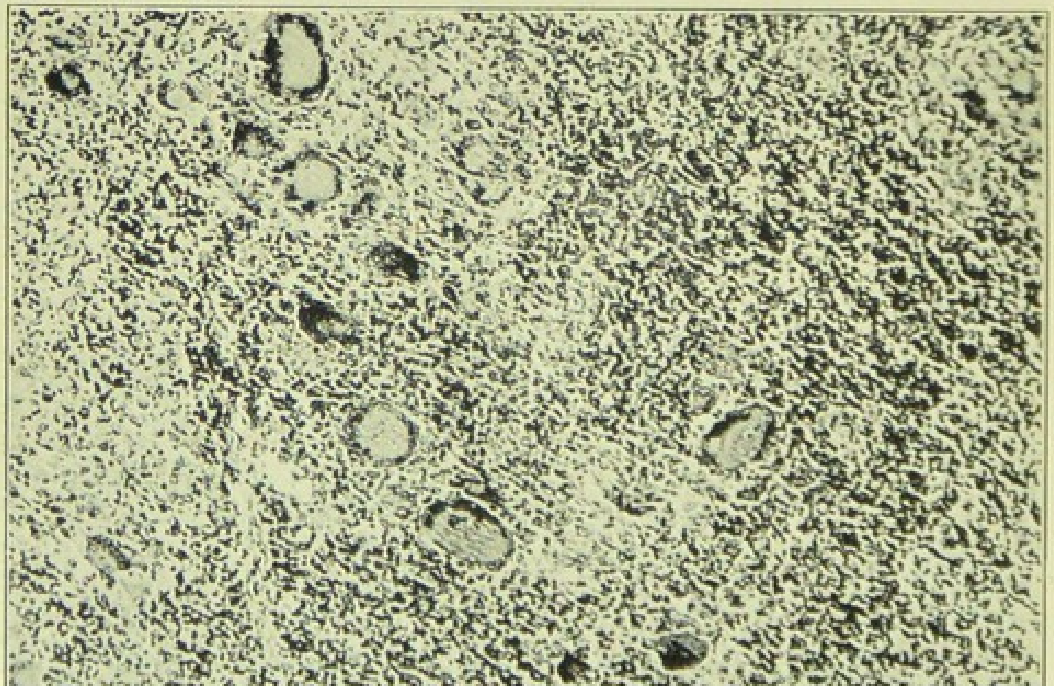


FIG. 22.—Section of mesenteric gland of cow suffering from Johne's Disease (showing giant cells; medium magnification). (The presence of giant cells in tissue is evidence of serious cell derangement, usually of an inflammatory nature.)

Points of Comparison with Tuberculosis.—Johne's Disease simulates tuberculosis in its insidious onset, the fact that healthy looking animals may be infected, and the emaciation of the animals in which the disease is developed. As we shall see later, there seems to be evidence of spontaneous recovery, as in the case of tuberculosis.

That Johne's Disease is not tuberculosis is shown, apart from the pathological evidence already cited, and, reasoning on broad lines, by the fact that the former is very often found in stocks which have failed to react to tuberculin and have shown no trace of tubercle formation. This applies especially to Jersey stocks both in Jersey and Denmark.

Concerning the formerly supposed identity of Johne's Disease with avian tuberculosis, Bang states that no connection between the two has ever been pointed out in practical life. No one has succeeded in infecting fowls by feeding intestines or mesenteric glands of cattle suffering with Johne's Disease. Conversely, the experiments of Oluf Bang, de Jong, and Mettam, on infection of cattle with avian tubercle bacilli, show that genuine tuberculosis is thus produced and bearing no pathological resemblance whatever to Johne's Disease.

Bang is of opinion, however, that a certain relationship must exist between the causal organisms of these two diseases.

Eradication.—The mode of eradication is practically the same as that for tuberculosis, and, as we shall see, the two may conveniently be combined.

DIAGNOSIS OF JOHNE'S DISEASE WITH AVIAN TUBERCULIN.

Oluf Bang's[1] recent experiences have convinced him that when a bovine animal reacts to avian tuberculin it may be safely concluded to be suffering from Johne's Disease, or, as it is known in Denmark, "bovine contagious chronic enteritis." This able assistant and son of Professor Bang reports the results of testing fourteen stocks containing 1,700 animals, in addition to forty-six cases of diagnosis performed by him on pathological material sent to the State laboratory. Most of the stocks consisted of tuberculosis-free Jersey animals.

He prepares avian tuberculin in the usual manner as follows: Surface cultures of pure avian tubercle bacilli are inoculated into glycerine peptone salt bouillon and grown for three to four months. The cultures are then sterilised by heating under pressure, the dead bacilli filtered out by means of filter paper, and the filtrate evaporated to one-tenth its volume.

Of this tuberculin he has employed doses varying between three-quarters of a gramme and two grammes. Before injection it is

1. Private communication. The remainder of this abstract of Oluf Bang's work is from the 66de Beretning fra den Kgl. Veterinær-og Landbohöjs. Laboratorium for landökonomiske Forsög, p. 41.

diluted with four times its volume of half per cent. carbolic water, so that 10 c.c. of the diluted tuberculin is equivalent to 2 gr. of tuberculin. The doses now employed are 10 c.c. of the diluted tuberculin for animals over two years of age. For animals between one and two years 7 to 8 c.c., and for animals between six months and one year 5 to 6 c.c. It has been determined that tuberculous cows which are not suffering from Johne's Disease do not react to avian tuberculin. Among the number of animals stated above only two were known to have shown false reaction, that is, evidence of disease could not be found on slaughter. The information under this head is admittedly scanty, however.

The specificity of the avian tuberculin was investigated by substituting virus prepared with the Timothy bacillus (which, as we have seen (p. 23), is claimed to cause reaction in tubercular animals), also the tuberculin from tubercle bacilli of cold-blooded animals. Neither of these produced reaction in bovines suffering from Johne's Disease. On the other hand, guinea-pigs were inoculated with the solution obtained by macerating the mesenteric glands of cows which had suffered from Johne's Disease in physiological salt solution. These experimental animals did not, as already stated, contract Johne's Disease, but a dose of 0·6 gramme of avian tuberculin proved fatal to them. Guinea-pigs which had not previously been injected with enteritis material survived the same dose of avian tuberculin.

The only observed effect of the injection of avian tuberculin into healthy animals is a slight decrease in milk yield such as might be accounted for by the disturbance in the stables.

Reaction, however, is sometimes characterised by diarrhœa and shivering, temporary loss of appetite and staring coat are more usual. At other times no change but high fever is visible.

Advanced cases of Johne's Disease do not react to avian tuberculin, just as similar cases of tuberculosis do not react to mammalian tuberculin. It was this fact which caused Oluf Bang to relinquish his experiments in June, 1907.

On re-testing thirty-four tuberculosis-free cows eight months after the first test, only 88 per cent. reacted. This is about the same proportion as Oluf Bang has found to occur with tuberculous stocks.

This evidence of oscillation, unfortunately, cannot be confirmed by *post-mortem* examination, as no trace of the disease remains when cure takes place—unlike tuberculosis, which leaves its evidences in calcified and encapsulated tubercles.

The total failures in the foregoing series of tests amounted to 7 per cent., which Oluf Bang considers no worse than one experienced with early tuberculin testing.

He recommends that avian tuberculin be mixed with ordinary tuberculin so that tuberculosis and Johne's Disease may be detected together, and the reacting animals immediately isolated and dealt with as circumstances determine. The most important step is, however, their prompt removal from among the healthy animals. The future of Jersey cattle in Denmark, he believes, will largely depend upon the issue of the struggle against Johne's Disease, and in avian tuberculin we have a means of early diagnosis which should prove a useful weapon.

APPENDIX C.

MORTALITY IN CALVES.

PROFESSOR C. O. Jensen, of Copenhagen, in his lecture[1] before the Royal Danish Agricultural Society, February 11th, 1903—"The Struggle against Mortality in Calves"—revealed a serious state of things among our Continental neighbours and a story of untiring energy in combating the trouble. "It is generally well known," he says, "that there is a very great mortality amongst newly-born calves, often even to such a degree that it is scarcely possible on a farm to get a single calf to live. This so-called calf mortality has different causes. It may be a poor development of the lungs, casual illnesses, or different bacteriological illnesses arising from the region of the navel, or, finally, the so-called calf diarrhœa.[2] The importance of the last named is exceptionally great. Just as one reads of complaints of a hundred years ago, one hears the same complaints to-day from America as well as from the whole of Europe, of difficulty in rearing calves.

Calf mortality

"The importance of the illness may be judged, among other indications, from the fact that some years ago a German University offered a large sum for a reliable method of combating the illness. Lots of humbuggers, patent medicine makers, have, with great advantage, interested themselves in the problem.

"The illness is only found during the first few days after birth; the forms of diarrhœa found in older calves are due to other causes. The calf is born absolutely sound, and generally only proves to be sick after about twenty-four hours, often not until two or three days after, rarely on the day of birth. Weakness sets in and signs of pains in the back appear, often accompanied with strainings. Usually diarrhœa sets in and gets worse under steadily increasing painful strainings. The weakness increasing, death ensues in the course of one to four days. Occasionally death occurs so quickly that diarrhœa has not had time to appear, the meconium not having passed. There are also cases in which the symptoms are milder, the diarrhœa extending over months, and the animal does not improve. Not infrequently the weakness of the animal permits milk and mucus to trickle down the air passages, and inflammation of the lungs intervenes; so that in protracted cases secondary immigration of bacteria takes place, causing sufferings in the joints and probably inflammation of the serous cavities.

1. Tidsskrift for Landökonomi, 1903.
2. Known in Britain as "White Skit," or "White Scour."

"The mode of appearance varies considerably. Sometimes it appears as an absolutely infective illness recurring year after year in the same stock. Again, it appears suddenly to disappear as suddenly as it arrived. At other times it appears in sporadic cases in an otherwise healthy stock."

When Jensen first attacked the problem some twenty years ago he was soon convinced of the bacterial origin of the disease, and resolved to exert his energies directly against the causal organism.

He was guided by the discoveries of Pasteur, who demonstrated the bacterial origin of various diseases, such as anthrax, infectious swine erysipelas, and fowl cholera, and immediately started to work on vaccination methods against them. Other workers had adopted the same course with regard to Blackleg. These methods, though directed by new processes of reasoning, were, of course, not new, as human smallpox has been treated on these lines for nearly a century. Similarly, sheep smallpox, pleuro-pneumonia, and other serious diseases in cattle had been treated by inoculation methods commonly known as vaccination.

The underlying principle of Pasteur's method was a reliance upon the process by which an animal itself recovers from a disease. This was, and still is, believed to depend upon the blood of the animal adapting itself to the poison produced by the causal organism. If this process be carried out gradually no serious consequences result. This is achieved by injecting into the blood stream of the animal a culture of the organism of weakened vitality, so that the animal tissues acquire the mastery over a debilitated foe (see p. 382), passing through a mild inconsequent form of the disease in this process.

Protective inoculation against sheep's braxy had been practised in Iceland and the Faroe Islands.

An improvement was introduced consisting in the inoculation of, not weakened living bacteria, but dead microbes or filtered cultures, *i.e.* liquids which contain the toxins formed by the organisms but from which the organisms themselves had been removed.

These again failed to give satisfaction, and it was at this stage in the investigation that State Consultant P. A. Mörkeberg requested Jensen to continue the investigation, which the latter worker agreed to do, "Little thinking," he says, "that I was undertaking a work which would occupy so many years." Since the beginning of the eighties the illness had raged with exceptional severity on the Ourupgaard estate of State Counsellor Tesdorpf, in spite of everything then possible having been done to resist it. In 1886-7 Mörkeberg himself stayed on the estate to study the disease. The mortality at this time amounted to 80 per cent. of the calves born. They succeeded in reducing the mortality by isolating the pregnant cows, by exceeding care of the calves and the use of suitable medicines, but still the result was unsatisfactory. Tesdorpf, therefore, desired researches undertaken to discover the cause of the illness and effectual means to combat it.

In the spring of 1892 Jensen[1] published the results of his researches, showing that the cause of the disease was the *Bacterium*[2] *coli communis*, which was taken in with the food, multiplied in the bowels, causing inflammation, in most cases gaining access to the blood stream and continuing to increase. It was also shown that the infective elements could penetrate the wall of the bowel, and that serious illnesses ending fatally could be produced by subcutaneous inoculation of the causal organism. Furthermore, bacteria of similar appearance were shown to be present in the bowel contents of healthy calves, and indications were obtained that the organisms in both cases were identical, having exerted a poisonous action only in the case of the sick calves.

The study of the disease was taken up by other workers in Germany, Holland, and Italy, a few cases due to organisms other than the *Coli bacterium* being recorded. Jensen also found such cases, but they were of rare occurrence. Their study, however, threw light on the main problem.

It seemed impracticable at this point to employ the latest advances in protective inoculation, which required at least a few days to secure immunity, seeing that, in view of the rapid course of the disease, the calf might easily die during the process. The most obvious alternative, however, appeared to be the immunisation of the calf before birth through the blood stream of the pregnant cow. Accordingly, vaccinations were made with increasing doses of calf diarrhœa bacteria cultures, also with cultures filtered through unglazed porcelain. These measures caused but little inconvenience to the cows, but it was soon found that they were quite ineffectual in securing immunity in the calves.

Jensen now turned his attention to antiseptic treatment of the digestive tract. Creolin and aniline violet colours (pykotannin) had been found to possess the power of killing bacteria while they were yet only weakly poisonous—sufficiently so, as it proved, however, to kill the calves even if they had not shown any signs of diarrhœa. Hence Jensen issues a warning against the so-called patent medicines which are sold as specific remedies for calf diarrhœa, *e.g.* vitulin consisting of creolin water and chalk, and for which a disproportionately high price is charged.

A different therapeutic line was now adopted—stimulation against the prominent symptoms of weakness. Cocaine, one of the most powerful stimulants then known, was employed, but no benefit was found.

Attention had now been drawn to the use of boiled milk proving beneficial for bowel complaints in human infants. This was tried

1. Maanedsskrift for Dyrlæger, Vol. 4, p. 140.
2. A bacterium is a short bacillus.

on the calves. "The experiments at Ourupgaard soon taught us," says Jensen, "that this was not the way to combat the illness, which developed in the calves far more seriously, and more of them died than before." It was shown repeatedly that perfectly healthy calves could not stand boiled milk during the first day of life. Of those which received it, nearly all died suffering from acute bowel infection characterised by bloody diarrhœa. On the other hand, it was found that if the calves received raw milk for the first day they thrived on boiled milk afterwards. This method is now extensively employed to diminish the risk from tubercular infection (Bang method).

At this point it appeared that possibly barley gruel or decoction of oat groats might be substituted with advantage for the boiled milk, which forms so nourishing a medium for bacterial growth. Laboratory experiments showed, however, that these substitutes were practically as good media as boiled milk, and practical trials on calves showed no advantage in resisting the disease, which continued its ravages at Ourupgaard.

Jensen now reverted to Mörkeberg's method of isolation of the newly-born calves, employing stricter precautions than the earlier investigator had observed. Improvement was noted at once.

When the calves, immediately after birth, were removed to a room where no calves had previously been born most of them escaped the illness; but if only one case of the illness had occurred the place became infected, and subsequent calves became infected. To secure more complete isolation a stable was erected farther away from the cow stable, and the new-born calves were taken there with great caution. This procedure gave still better results, but could not be considered a satisfactory solution of the problem, in a general way, on account of the trouble and expense involved.

Various observations made from time to time at Ourupgaard had caused Jensen to suspect that, from some cause or other, the severity of the illness at that place might be connected with an arrested development of the digestive glands of the calves at birth—perhaps a lack of digestive ferments in the stomach and bowels. To determine this point small quantities of diarrhœa bacteria, digestive ferments, *e.g.* pepsin, trypsin, and various extracts from stomach and bowel mucous membranes and gall, were added to the milk. After repeated experiments no benefit was found.

At this stage of the investigation, in the face of so many failures, Jensen, though still undaunted, seemed to have realised that it was no simple task he had undertaken.

The situation admitted of no relaxation of effort, however, as the calves continued to die.

New hopes were raised by the brilliant discoveries of Behring and Kitasato of antitoxins in the blood of immune animals.

It was shown, for example, that an animal which had been repeatedly treated with tetanus organisms (lockjaw), but in such a manner that the animal did not succumb to the disease, produced in its blood certain substances which act as an antidote to the poison of tetanus, so that when an opportunity for ordinary infection occurs the animal is able to resist and remains partially or completely unaffected. Such an animal is said to be immune or insusceptible. It was further shown that the transference of blood from such an artificially immunised animal—even a small quantity of blood—into a second animal resulted in a similar immunity. The substances which confer this property to the blood were appropriately termed antitoxins. These substances exist in solution in the liquid elements of the blood, hence the corpuscles, being unnecessary, are removed by coagulation and the serum after filtration, termed immune serum, utilised in protection against the disease it is designed for. Such preparations have been found valuable for human diphtheria, Asiatic cholera, and typhoid fever, swine fever, tetanus in horses, etc.

Jensen at once started to prepare an immune serum with the *Bacillus coli communis* by injecting the organisms into a strong animal, *e.g.* a horse. Increasing doses were introduced at suitable intervals. To determine the efficiency of the immunisation some blood was drawn from the horse, a definite volume injected into a smaller animal, which was then exposed to the infection of the calf diarrhœa, and the result noted. Mixing the bacteria with the immune serum and injecting into the peritoneum of a guinea-pig proved a good method, and it was soon found that sera of remarkably strong protective power could be produced.

Newly-born calves were vaccinated with the serum and immediately fed with milk in which a small quantity of the diarrhœa bacteria had been mixed. The results were satisfactory.

A veterinary assistant lived on the estate for two winters and vaccinated some of the calves immediately after birth. The results were not satisfactory, as they only showed a slight advantage in favour of the inoculated animals.

Jensen had discovered, however, that the bacteria isolated from the fæces of the diseased animals were not all identical. There appeared to be different races. Similar observations had been made with regard to bacteria of dysentery and swine fever, but at this time it had never been suggested that such small differences in strain need be taken into account in preparing immune sera.[1]

Slight as these differences were, however, Jensen suspected they were the cause of the failures. He then spent two years investigating difference in race of the diarrhœa bacteria, and published the results of his investigations.[2] The modes of differentiation employed were

1. The recent researches of McConkey show that these small differences constitute proof of absolute separate identity, and that under the name of *Bacillus coli communis* Jensen was really dealing with a number of distinct organisms (see Section III.).
2. Biologisk Selskabs Forhandlinger, 1897-8, S. 4 and 29; also 1899-1900, S. 11.

the fermentation of various sugars, arabinose,[1] xylose, rhamnose, etc., and the alcohols dulcite, adonite, glycerine, etc., also the agglutination test (see p. 403).

When the serum of the immunised horse was tested against the various strains of the *Bacillus coli* isolated, it was found that agglutination by means of immune serum occurred with some, but there was absolutely no effect with others. It was, therefore, clear to Jensen that the races were so far different that one kind was not affected by a serum produced by the help of another.

Similar results with other animals' diseases have since been discovered. Wasserman and Ostertag have, by extensive investigations, proved the existence of sixty or seventy different races of a swine disease bacteria (the disease known in Denmark as infectious pneumonia, swine pneumonia, swine disease, etc.; in America as swine-plague) which are different as far as the effects of serum are concerned. Similar conditions have also been shown as regards strangles.

It was now clear to Jensen that he must carry out his laboratory work on a much more extensive scale. He applied to the Danish Ministry, and was readily granted facilities in the State Laboratory of Experimental Pathology and funds to pursue his investigations. The original intention was to produce various sera specific each for a single race of bacteria. This appeared too laborious and expensive, however, so Jensen evolved the idea of immunising the one horse against the two races at the one time. After some accidents, in which several horses died partly from casual causes, partly as a result of the vaccination, he succeeded in producing such a serum in a limited period. It was found that vaccination of about 10 c.c. of this serum into calves effectually protected them against some few strains of diarrhœa bacteria, but not against all.

Attempts were renewed at Ourupgaard, but owing to complicated conditions were not satisfactory. The serum was offered gratis to the veterinary surgeons in Denmark.

Dead calves from affected stocks were sent to the laboratory, the causal bacteria isolated, and the effect of the serum on the organisms observed. If the serum proved not to be specific for the organisms concerned, none was sent. On a number of large estates the results have altogether been good. Hardly any of the vaccinated calves died, whilst there was a high mortality amongst those which had not been treated. Cases in which serum was sent to estates from which calves had not been sent in proved very uncertain.

Hearing of Jensen's results, the Chamber of Agriculture of the province of Saxony approached him with a request for a supply of serum. The Chamber have a large depôt in the cattle square in Halle a/Salle for the sale of cows in calf. Amongst the new-born

1. See work of Savage, Section III.

calves dropped by the cows passing through this depôt diarrhœa was so rife that hardly a single calf lived. Among the various institutions working under the Chamber of Agriculture is a bacteriological laboratory directed by Dr. Raebiger, who had not succeeded in finding means of combating the disease, but as a result of Jensen's serum inoculation obtained the following results :—

From middle of September to middle of December, 1901, 98 calves were born at the depôt. Of these three were still-born. Forty-seven calves were sold within a few days after birth, together with their dams. Almost without exception these calves died and the usual claim was paid.

Forty-three calves remained at the depôt. Of these 24 were not treated with serum, and they all died ; 19 were vaccinated, one died from diarrhœa, and another from other causes.

The treatment was continued with satisfactory results until May, 1902, when the serum appeared inefficient. This was explained by the fact that the horse producing the serum suffered from a serious blood poisoning from the calf diarrhœa toxins. The animal grew as thin as a skeleton, and only after about six months partly recovered. The serum obtained after recovery proved effective.

Subsequently Jensen produced a serum after vaccination of eleven different races of diarrhœa bacteria into the same horse. This serum is now being sold by the Royal Danish Serum Laboratory.

After perusing the account of so distressing a struggle many a reader will feel thankful that he has not met with such expensive reverses. Speaking for ourselves, about 5 per cent. of our calves die.

In July, 1909, Jensen issued from the Royal Veterinary and Agricultural High School Serum Laboratory, Copenhagen, a concise statement of the causes and treatment of calf scours. He says they are principally due to (1) navel infection ; (2) calf diarrhœa. The most infectious diseases in older calves are : (3) para coli infection ; (4) septic pleuro-pneumonia ; (5) other kinds of pneumonia ; (6) calf diphtheria.

(1) *Navel infection* is combated by cleanliness, attained by antiseptic binding of the navel string, as the inflammation can be due to various kinds of bacteria. An effective prophylactic[1] treatment is difficult.

(2) *Calf diarrhœa* is an illness of the bowels caused by various microbes. Most cases are due to the action of one or other of the races of colon bacilli (bacilli which live in the bowels). Other causes are rare. It is not easy, by histological methods, to determine whether colon or para colon bacilli are the causal organisms. (Para colon bacilli are those which vary in type from the majority of the colon

1. "Prophylactic"—on the lines of prophylaxis—a term denoting the use of precautionary measures in the treatment of disease—the attempt, that is, to cure the disease before its reality is demonstrated.

—large main part of the large bowel—organisms.) In the case of the latter organisms, however, the spleen is more or less swollen, and it is not unusual to find fibrous inflammations in the thoracic cavity, pericardium, and joints. To definitely determine which bacteria are the cause of the illness, a bacteriological examination is necessary, and for this purpose it is usual that a dead but fresh calf is sent in for examination. The laboratory produces partly a coli serum and partly a para coli serum. For both a number of varieties of the bacteria in question are used.

As these sera could not be supposed to be effective for all cases, the laboratory will in the future in every case in which the serum is ineffective employ the varieties found in the case for the production of a special serum. For the production of coli serum horses are used which have been treated for a long time by intravenous injection of living cultures of a great number of bacteria. The serum is used for protection, but its curative effects on young calves is uncertain. As a means of protection the serum must be injected under the skin of the calf as soon as possible after birth. Until further notice the dose must be 15 c.c. A well-cleaned syringe is used for the injection, and the point of injection must be well cleaned by washing before the injection. The serum injection itself cannot do any harm. If the serum causes any effect at all, all other means of struggling against the disease will be superfluous. As means of protection a dose of 15 c.c. is used. For curative purposes 30-35 grammes must be used, and it should then be injected into various parts of the body, and if necessary the treatment repeated. An antiseptic has been added to the serum, and it can, therefore, when it is kept clean and in a cool, dark place, remain effective for many months.

The serum treatment is ineffective against a hitherto little-known form of diarrhœa occurring in some stocks, especially Jersey stocks.

In other stocks this illness has been prevented by the use of extract of pancreas.

Not unusually several forms of calf diarrhœa are found in the same stock at the same time, which, of course, complicate the problem and necessitate extra work in diagnosis.

(3) *Para coli infection* attacks calves of all ages, occasionally also mature cattle. In some stocks only young animals are attacked (see under 2), in others both young and old. The disease is very liable to persist in the stock attacked for years. Sometimes it shows itself as a fatal, more or less, violent inflammation of the bowels, sometimes as pneumonia without tendency to decay, less frequently as a septic fever without special localisations. In some stocks pneumonia and bowel disease occur simultaneously, in others only a single form of the illness. By the use of para coli serum one is usually able to combat the disease in stocks ; 15 c.c. is used for prevention, also for larger calves. If the disease persists in the stock it is best to repeat the treatment in the course of three or four weeks.

For treatment 30 to 45 c.c. are used. If necessary the treatment is repeated after two or three days. As the disease is very liable to persist, a rigid isolation of the diseased stock is advisable ; or, better, *the killing of those whose flesh is dangerous to the health of human beings*, followed by thorough disinfection.

(4) Septic pleuro-pneumonia and game disease are forms of the same illness which are caused by bacteria belonging to the hen cholera group. In cases of inflammation of the lungs, one finds a fibrous dark-red covering over the pleura and infiltrations like jelly in the inter-lobular spaces. In cases of game disease the alterations in the organs are not easily seen. For combating the illness, isolation and disinfection are recommended, aided by two preparations—immune serum and another serum containing dead bacilli. The one is used as a preventive, the other as a curative for animals suffering from the disease.

(5) Besides the pneumonia caused by para coli bacilli and the septic pleuro-pneumonia, other forms of inflammation of the lungs are not infrequently found about which little is known. The most frequent is infectious bronchial pneumonia. Against this form, in which one finds enormous quantities of the *Bacillus pyogenes*, the laboratory is making investigations.

(6) *Calf diphtheria* is best combated by killing the animals attacked and removal of the sound ones. Serum treatment has not yet been tried.

Coli and para coli serum are delivered in 15 c.c. doses costing 25 øre (3½d.). According to the circular of May 15th, 1909, of the Ministry of Agriculture, veterinary surgeons are empowered to demand 50 øre per dose.

" A NEW METHOD OF TREATING CALF SCOURS.

In 1906 the U.S. Department of Agriculture published in their Farmers' Bulletin, No. 273, the following abstract of the Maryland Experiment Station, Bulletin No. 86, and South Carolina Station, Bulletin No. 122.

" As pointed out by L. A. Klein, of the South Carolina Station, one of the most common difficulties met with in raising calves on skim milk is the persistent form of diarrhœa commonly known as calf scours. This disease is due to the action of various fermentative and putrefactive bacteria in milk. As is generally known, the undue growth of bacteria in milk may be largely prevented by the exercise of strict precautions from the time the milk is drawn from the cow until it is fed to the calf. The necessary precautions, however, involve more attention and labour than can always be expected from the average dairyman. The inevitable result of carelessness in handling milk is the development of large numbers of bacteria in it, and this in turn leads to calf scours, which always causes an unthrifty condition in the calf and may often produce death.

"Proceeding on the basis of the results of investigations by von Behring, the Maryland Experiment Station and the Bureau of Animal Industry of this Department on the influence of formalin on disease germs and on digestion when administered in small amounts in milk, Dr. Klein treated twelve milk-fed calves affected with scours by adding formalin to the milk in the proportion of one part to 4,000 parts of milk. This dilution may be readily obtained by pouring 0·5 ounce of formalin into 15·5 ounces of water. From this stock solution one teaspoonful is added to each pint or pound of milk to be fed to the affected calf.

"From the experiments just outlined, it appeared that the results are practically the same whether the formalin solution is placed in the milk just before feeding to the calf or immediately after the skim milk is received from the separator. Apparently, however, it was advisable to add the formalin to the milk immediately after separation. Of the twelve calves treated in this way, eleven recovered without any further treatment, seven of them on the second day, three on the third day, and one on the ninth day. If further experiments show that formalin causes no injury to calves, this method furnishes an effective and practical means of controlling calf scours."

The researches of Metchnikoff have thrown a new light on the question of intestinal bacterial action, and it is not surprising that the principles of this distinguished investigator should have yielded good results in calf rearing.

We have already seen that diarrhœa in children has been successfully treated with sour milk (see Section III.). Dornic and Daire[1] consider that the solution of the grave question of calf diarrhœa must be sought on the same lines—adjustment of the races of bacteria in the intestine—which thus become the key of the problem of successful calf rearing.

They found some calves that swelled up after each meal and whose excrement was foamy and discharging bubbles of gas. The cause was traced to a yeast in the feeding meal, which was immediately discarded.

In another calf the green and viscous diarrhœa was traced to a certain microbe the origin of which could not be determined.

Finally, in many cases of black and fetid diarrhœa a diplobacillus was found to be the cause. On subculture this organism produced diarrhœa when eaten by rabbits, and when injected produced abscesses containing fetid and caseous pus.

Dornic and Daire ascribe the increased liability of Pasteurised milk to decomposition to—

(1) The decreased digestibility of the Pasteurised milk (as shown by the delayed action of rennet) produces stagnation in the stomach, and thus provides the opportunity for more abundant bacterial action.

1. Rapports et Comptes-rendus des Séances. Deuxième Congrès National d'Industrie Laitière, p. 105.

(2) Pasteurisation destroys the lactic acid bacilli which, according to Metchnikoff, Bienstock, Tissier, and Martelly, play the part of intestinal police service; thus the fermentation organisms were relieved of opposition.

On account of the possibility of tubercle bacilli being present in the milk, these authorities insist on Pasteurisation, however, and overcome the tendency to diarrhœa by the addition of a small quantity of lactic ferment added to the usual food about every alternate day. This procedure was found to suppress diarrhœa and diminish (often eliminate) the foreign ferments in the fæces. It is also recommended that separated milk from dairies be used with the following precautions:—

(1) Pasteurise the skimmed milk at the dairy at 153 or 162° Fah. for five minutes.

(2) While still at the dairy, add 1 cubic centimetre of 30 per cent. or 40 per cent. calcium chloride solution to each litre of milk.

(3) Feed the milk with clean, well-kept feeding bottles.

(4) Keep small meshed muzzles on the calves.

(5) Every two or three days mix with the food about a litre of milk curdled by an active lactic ferment.

The same treatment had proved very successful in rearing pigs during two years.

Malpeaux[1] recommends the addition of lactic ferment to milk for calves.

Dornic and Daire,[2] after further experience, confirm their previously expressed views, and state there is no difficulty in preparing sour milk for calves on the farm. They say: "Boil the milk in any vessel, and after cooling to about 122° Fah. introduce the ferment, preferably liquid. The vessel is now placed in an insulating material such as wool, flannel, cork, shavings, etc. The temperature will remain above 86° Fah. for several hours, and coagulation take place. It is then only necessary to mix the curdle to the skimmed milk intended for the calves."

In confirmation of Jensen's statement regarding the high mortality of calves and of the French workers' success in combating it by means of lactic acid bacilli, we find an example nearer home. Mr. Sillito, of Chetwynd, Aston, Newport, Salop, addressed a letter to the Salop County Council, February 22nd, 1910, asking for assistance in investigating the cause of calf mortality on his farm. During his four years' tenancy Mr. Sillito had never succeeded in rearing a calf from his herd of 50-60 cows on a farm of 232 acres.

The previous tenant had the same experience, but found that calves brought in thrived quite well. Other farms in the same district

1. Rapports et Comptes-rendus des Séances. Deuxième Congrès National d'Industrie Laitière, p. 112.
2. Rapports et Comptes-rendus des Séances. Troisième Congrès National d'Industrie Laitière.

had suffered also. The County Council were unable to vote any funds for an investigation, but the matter was taken up by the Harper-Adams Agricultural College, Newport, Salop, whose veterinary lecturer, Mr. W. T. Wilson, F.R.C.V.S., issued a report,[1] which we have abstracted hereunder.

Mr. Wilson made visits to the farm and observed symptoms at all stages. In the later periods of the disease the symptoms were those of " infectious white scour," known as the " Gurr " in Staffordshire. *Post-mortem* examination of a calf, which was slaughtered when practically *in extremis*, convinced Wilson, however, that infectious scour was not the trouble, and although handicapped very considerably from the want of a complete bacteriological examination, formed the opinion that the disease was one of the septicæmias of young calves. The infecting germ he believed to be taken into the body through the alimentary canal with the first sucking of the teats and withdrawal of the milk. When carried into the fourth stomach the germs grew so rapidly that they soon overpowered the ordinary lactic and other digestive bacteria natural to the process of milk curdling. It then became a question of " The survival of the fittest." If the natural germs gained the ascendancy the calf lived; on the other hand, when the infectious germs outnumbered the natural ones, they multiplied so rapidly, were absorbed into the blood stream, were distributed to the lungs, where they or the toxin product formed during their growth set up secondary lesions, as " septic broncho-pneumonia," from which the calves soon died.

This secondary change was observed *in all stages* in *every* post-mortem made, and shown also during life, as the farmer himself experienced, knowing when a calf was approaching death by the animal commencing to " blow "—a symptom also observed by Wilson.

In all cases the calves were to time, strong, and healthy *at birth*, taking their milk readily until the *third* day, when they became dull, drowsy, and sleepy, continually lying down, and even when forced to get up they were weak and helpless, refusing their food.

On taking the internal temperature immediately the first symptoms of dullness, etc., were noticed, it was always found high and continued to rise until a few hours before death, then dropping sometimes below normal.

While Mr. Wilson was engaged in the investigation on Mr. Sillito's farm a similar outbreak occurred on a neighbouring farm, where the last thirteen cows had calved strong, healthy calves, and *every calf had died*, although every precaution had been taken.

This farm was also taken in hand by Mr. Wilson, who thus had thirty-six calves under observation during life and conducted *post-mortem* examinations on eight.

1. Supplementary Bulletin to Annual Rept., 1909.

Symptoms.—In all cases the symptoms followed a definite course throughout. From the second to the third day (depending upon the strength of the animal) the first symptoms were a weeping from the eyes, which continued until the fourth or fifth day, when it became almost purulent and inflamed the eyes, exactly similar to distemper in the dog. Then the animal gradually becomes weaker, losing flesh very rapidly, continually lying down, sleeping and drowsy, with its head turned to one side, the eyes sink in the head, muzzle dry, refuses milk altogether, falls away to a skeleton, ending in a miserable object.

On the seventh to the ninth day the calf is powerless, passes into a comatose condition, commences to " blow," and is soon dead.

A few hours before death there may be slight diarrhœa, which becomes thin, yellowish-white, and stinking, but not in all cases.

Post-Mortem Examination.—The changes were confined to the lung tissue: in some cases only the apices of the lungs showed discoloration, in others a large portion of the lungs was involved.

On cutting through the lung substance evidence of broncho-pneumonia, even to small abscesses, in all stages was seen.

The stomach and bowels throughout showed hardly any changes whatever, except masses of hardened curd in the fourth stomach and slight traces of patchy inflammation here and there through the mucous lining of the bowels.[1]

The liver and kidneys, on section, were soft in some cases and distinctly spotted with red coloured centres.

Treatment.—In both outbreaks a fresh box was prepared, thoroughly limewashed and disinfected.

As soon as the calves were born, the navel was tied at once with an antiseptic thread, and painted over three times with a dressing of carbolised collodion, 1–10; another dressing applied twelve hours afterwards. (No evidence of infection through the umbilicus had been found on *post-mortem*, but the above important precaution was considered advisable.)

The calves were then removed into a perfectly new box where calves had never been before, or, in the second outbreak, small pens were made in the rick-yard and hurdled round. Each calf was given a quart of skimmed morning's milk with a pint of warm water added for three meals; to these milks a teaspoonful of a preparation containing living lactic acid bacilli was added.

On the second day new milk was gradually added to each meal, and the preparation added to every lot of milk.

The quantity of new milk was increased until the ninth day, when the preparation was discontinued.

Not one calf of all the number showed any symptoms of illness whatever, and never looked back from the time of birth.

1. It is usual to find the membrane of the fourth stomach swollen with a macerated or soaked appearance. There are often small red patches seen in the bowels and other organs (Petichiœ).

Wilson is of opinion that the active lactic bacilli taken in thus with the milk at each meal overcame any infectious germs that might be present.

The strictest cleanliness was observed with the pails, these being thoroughly scalded after each lot of milk.

All manures were disinfected with quicklime and buried in the garden, the floor of the calf box limewashed, disinfected, and thoroughly sprinkled with quicklime before the clean straw was littered down.

Wilson is continuing the above treatment on other farms addicted to white scour, and the reports so far to hand have proved the treatment a success in every case.

APPENDIX D.

DESTRUCTION OF RATS.

THE following is a summary of a collection of articles written by the employees of the United States Public Health and Marine Hospital Service engaged in rat catching at San Francisco, Cal. These men have demonstrated their knowledge of the subject by continuously large catches, and what is detailed here is the result of actual experience.

Rats are to be found where there is an abundant food supply for them. Therefore, the best places to trap rats are slaughter-houses, meat markets, chicken houses, in and around garbage cans, and places where garbage is usually placed. If the rat is deprived of his food supply it will be attracted by the bait in the trap and thus enter the trap.

The large 19-inch French wire cage trap has given very good results where rats are plentiful. It should be made of stiff, heavy wire and well reinforced, as a large strong rat will force his head between the wires of a weak trap and thus escape. Before setting, the lever on the trap should be tested to see that it works properly. The trap should be placed on a hard surface with the rear end a little higher than the entrance, so that the trap will close promptly. When setting the trap in an open place it should be fastened to a board on which about an inch of soft dirt has been spread. Place the trap where rats usually go for food, or in a runway, and disturb the surroundings as little as possible. It is sometimes well to place the trap near dripping water, as the rats may go there to drink. If the trap is set in hay, straw, or wood, it should be covered (with the exception of the entrance) with the same material. When this is not possible, it should be covered with a piece of sacking, or placed in a dark corner, or beneath the floors. When setting the traps in the sewer a dry place should be chosen.

The rat is more or less of an epicure, therefore the bait should be changed at frequent intervals. For bait the rat should be given food which it is not usual for him to obtain. In a meat market, for example, vegetables are the best bait, while in a location where vegetables are plentiful, fresh liver and fish heads or a little grain are best. The following may be suggested as good bait to be used: Fish, fish heads, raw meat, cheese, smoked fish, fresh liver, cooked corned beef, fried bacon, pine nuts, apples, carrots, and corn. When trapping in chicken yards a small chick or duckling is a remarkably good bait.

When a large number of rats are caught in one trap, search for the female rat and leave her alive in the trap, as she may call in the young or the males. The bait should be fastened to the inner side of the top of the trap with a piece of fine wire, so that the first rat that goes in cannot force the bait underneath the pan and thus prevent the entrance of other rats. A few grains of barley should be scattered near the entrance of the trap and a small piece of cheese or meat fastened to the pan with a bit of wire. It is often well to touch the pan with a feather which has been dipped in oil of anise or oil of rhodium. The trap should be smoked with a piece of burning newspaper to take away the smell of the human hands, or of rats which have been caught in the trap. Do not handle the trap after burning it out. When trapping in a neighbourhood where rats are known to exist, the traps should not be moved for three or four days unless they have rats in them, as it is well for the rats to become accustomed to seeing the traps and thus careless about entering them. It is not wise to kill rats where they are caught, as the squealing may frighten away the other rats.

Snap or spring traps are best for use in houses and stores, with the exception of fish and meat markets. Snap traps are best for use in runways and on beams and shelves. It is sometimes well to disguise the trap by covering its floor with a little sawdust or dirt. The traps should first be tested to see that they work properly, and that the staples are secure. New traps should be smoked or stained to render them of an inconspicuous colour.

The bait should consist of some firm material, such as fried bacon or tough meat, and should be tied on so that the rat will be obliged to pull on it and thus spring the trap. The trap should be placed in a corner or close to the wall on a flat, hard surface in order that the rat cannot spring it with his tail or by walking on it.

In warehouses and granaries large numbers of rats may frequently be trapped by using a barrel or garbage can having a metal top which is carefully balanced. A large piece of strong cheese is placed in the middle of the cover and a plank laid from the floor to the edge of the barrel. The rat runs up the plank and on the smooth metallic lid, which tips, precipitating the rat into the barrel.

W. R. Boelter[1] desires to enlist public opinion in the crusade against rats and other vermin, and thus pave the way for the passing of a Bill drafted on the lines of the Danish Rat Law by the Incorporated Society for the Destruction of Vermin. Boelter suggests there are in this country at least as many rats as there are human beings, and as a result of certain rat-feeding experiments and systematic inquiry among landowners, farmers, shopkeepers, shipping, dock, and colliery companies, and others, the annual resultant loss of food and other material is computed at £15,000,000.

1. The Rat Problem, by W. R. Boelter. London : John Bale, Sons & Danielsson, Ltd., 1909. Review in Brit. Med. Jour., Jan. 9th, 1909, p. 95.

Boelter describes the channels of communication between the rat and man, resulting in the propagation of trichinosis and plague, and deprecates the ruthless destruction of some of the natural enemies of the rat—the owl, weasel, and kestral.

Numerous mechanical devices for exterminating rats are described. Many of these are said to be very efficient in the hands of experts who are familiar with the habits of the animal. Boelter appears to favour Neumann's virus (ratin), partly because it is supplied in a form for convenient use by inexperienced persons.

Dr. Herbert Williams,[1] Assistant Medical Officer of Health, Port of London, states " It is practically impossible by any means to do more than keep down the natural increase in the number of rats.

" The means employed—

" (1) Traps.

" (2) Animals, *e.g.* cats, dogs, ferrets, and mongooses.

" (3) Poisons.

" (*a*) *Chemical Poisons.*—The chief chemical poisons are arsenic, phosphorus, strychnine, carbonate of barium.

" (*b*) The *pathological poisons* are very numerous; they have been tried at various times in the Port of London, but I cannot satisfy myself that any practical success has attended their use.

" It is claimed that they either destroy the rats or drive them away from the locality.....

" Probably the most fatal disease that can be communicated to rats is plague.... and in countries where plague exists among rats it certainly does not exterminate the rats. I am, therefore, unable to see that the various pathological poisons are likely to be more fatal to rats than the plague organism."

In this connection we may remark that a considerable difference exists between the accidental infection of rats with their most virulent disease, and a systematic and continuous administration of a less virulent virus with their food.

1. Rept. of the 26th Congress of the Royal Sanitary Institute, Belfast, 1911.

APPENDIX E.

AVIAN TUBERCULOSIS.

CHAS. H. HIGGINS, B.S., D.V.S.,[1] refers to the increasing prevalence of tuberculosis among poultry in Canada. This pathologist of the Canadian Department of Agriculture states that "....any measures for the suppression of the disease must be drastic and efficiently carried out that all infective material may be destroyed. The destruction of the fowls followed by thorough disinfection of the quarters and the ploughing up of the runs will usually prove effective. New stock should be raised from the egg, and care taken to determine that the parent stock from which the eggs come is free from this or other diseases."

Mr. Gilbert, the poultry manager of the Experimental Farm, states that in one instance where the instructions given in a laboratory report were followed, the disease was completely eradicated, and that in another instance, where the owner preferred to run the risk of losing his entire flock, that losses have been constant, and that the evidence available would indicate that this particular flock had been the source of a number of smaller outbreaks.

1. Rept. of the Veterinary Director General and Live Stock Commissioner, Dept. of Agri., Canada, 1911, p. 67.

GLOSSARY.

Abdomen—The belly, the cavity situated between the thorax and the pelvis.

Abnormal—Unnatural; irregular.

Abortion—Bringing forth young prematurely; miscarriage.

Abrasion—A superficial part scraped into fine shreds.

Abscess—A swelling or "gathering" containing pus (matter).

Absorb—To soak up.

Actinomycosis—The disease produced by the growth of actinomyces in the tissues.

Acute—Of considerable severity, rapid progress, and short duration as distinguished from *chronic*—long continued and of lesser severity.

Affection—Disease.

Agglutination—The adhesion of moving bacteria into sluggish clumps.

Albumen—A constituent principle of plants and animals, the white of egg. The serum of the blood is nearly pure solution of albumen.

Alimentary—Pertaining to the alimentary canal; the entire passage through which the aliment or food passes; a musculo-membranous tube extending from the mouth to the anus.

Alveoli (plural of *alveolus*)—A little channel. The air cells of the lungs are termed "alveoli."

Anæmia—Deficiency of red corpuscles in the blood. Also deficiency of blood.

Anaphylaxis—A peculiar state of sensitive avidity of body cells produced by the presence of anaphylactin, a constituent of serum according to Gay and Southard.

Annihilate—To reduce to nothing; to destroy the existence of.

Ante-natal—Before birth.

Anthracis—Of anthrax.

Antidote—A remedy against the action of poison.

Antiseptic—That which prevents decay by destroying the organisms which cause it.

Antistaphylococcic—Exerting action against staphylococci.

Antitoxin—A substance capable of neutralising the effects of a toxin. Both the toxin and the antitoxin are produced by the action of microbes on the living tissues.

Anus—Opening from the rectum, or back bowel.

Areola—The pink or brown circle which surrounds the nipple of the female breast.

Arsenical—Containing arsenic.

Arthritis—Inflammatory disease, acute or chronic, of the whole or greater part of the structures that enter into the formation of a joint.

Articulated—Jointed.

Ascites—Dropsy of the belly, or abdomen.

Assimilation—The process of abstraction of nourishment from food.

Astringent—A medicine to cure looseness of the bowels.

Attenuated—Weakened. The attenuation of bacteria results from their living under unfavourable conditions.

Auricle—A cavity of the heart.

Auscultation—The act of listening by the application of the ear in the examination of disease. Usually assisted by a stethoscope.

Autopsy—Dissection and examination of a body after death.

Axillary—Belonging to the arm pit (the space between the side of the chest and the shoulder).

Bactericidal—Fatal to bacteria.
Bacteriolysis—The disintegration of bacteria by specific ferments.
Bacterioscopic—Involving an inspection of bacteria.
Barium chloride—A compound of barium and chlorine.
Biological—Concerning the nature and structure of living organisms.
Bo-phthisis—Human phthisis of bovine origin.
Bovine—Pertaining to bulls or to the bull species.
Bronchia—Branches of the windpipe.
Bronchial—Pertaining to the bronchia.
Bronchitis—Inflammation of the bronchial tubes.

Cachectic—Affected with cachexia; a bad habit of body; the expression of a general defective nutrition of the various tissues the result of chronic maladies, or of such diseases as cancer and syphilis.
Calcareous—Partaking of the nature of lime or chalk; containing lime.
Calcium chloride—A compound of calcium and chlorine.
Carbolised—Containing carbolic acid.
Carbon—A black chemical. Lamp black and graphite are impure forms.
Carbonate—A compound with carbon.
Carnivorous—Eating or living on flesh.
Casein—A constituent of milk. That which forms the curd.
Caseous—Like cheese.
Catheter—A tube used for extracting urine from the bladder or milk from the udder.
Causa sine qua non—An essential part of the cause.
Caustic—That which corrodes the flesh.
Cellular—Consisting of or containing cells.
Centrifugation—The operation of submitting to centrifugal force; that force by which all bodies moving round another body in a curve tend to fly off at any point of their motion. The intensity of the force depends upon the density of the body, hence substances of high density displace those of less density, and separation results.
Centrifuge—A machine for separating the lighter from the heavier portions of a fluid mass by centrifugal force. A milk separator is a centrifuge.
Cervical—Pertaining to the neck.
Cervix—The neck.
Cestode—An intestinal worm belonging to the second order in Zeder's system of the entozoa, which comprises tapeworms.
Chronic—Of long duration and comparatively slight severity as distinguished from *acute*—of short duration and greater severity.
Cicatrised—Showing the marks left after the healing of a wound or ulcer.
Cilia—Microscopic hairs of a vibratile nature abundant in the lowest forms of animals.
Cladothrices—A class of micro-organisms resembling bacteria.
Coagulation—The process of thickening or becoming viscous.
Coalesce—To unite and adhere in one body or mass; to grow together.
Cohabitation—The act or state of cohabiting; living together.
Collaboration—The act of collaborating or working together; united labour.
Collodionised—Covered with collodion, a solution of gun cotton in ether which on drying leaves a transparent film or coating. Collodion is used in surgery and photography.
Comatose—In a deep sleep. A term implying a morbid condition of the brain, attended with loss of sensation and voluntary motion.
Congenital—A term applied to diseases which creatures have at birth.
Congestion—The gathering of blood to a certain part.
Conjunctival—Pertaining to the conjunctiva, the mucous membrane which covers the cornea, the front part of the sclerotica, and turns back over the inner surface of the eyelids.
Consolidation—The act of consolidating; making solid, firm, or dense.
Contagious—Transmissible by actual contact.
Cornea—The transparent horny portion of the external tunic of the eye, fitting into the sclerotica as a watch-glass fits into its frame.
Corrosive sublimate—The bichloride of mercury.
Crustaceous—Having a crust or shell.
Cutaneous—Belonging to the skin; existing on or affecting the skin.

Decapsulated—Deprived of capsule, membranous covering, or envelope.
Decomposition—The process of decay.
Deglutition—The act of swallowing.
Demarcation—Act of marking off, or of ascertaining and setting a limit.
Denudation—Act of denuding or making bare.
Devitalised—Deprived of life or vitality.
Diagnosis—Arriving at a conclusion as to what disease is present.
Diagnostic—Characteristic ; indicating the nature of a disease.
Dialyser—The parchment paper or septum used in dialysis, the act or process of separating crystalloid elements from colloid elements.
Diaphragm—The midriff, a muscle separating the chest or thorax from the abdomen ; a partition of various kinds.
Diplobacillus—A double bacillus.
Disinfectant—A substance having the power of destroying germs.
Disseminated—Scattered for growth and propagation (as seed) ; spread abroad ; diffused.
Domestic—Used by man (as domestic animals).
Dorsal—Pertaining to the back.

Efficacious—Effectual ; having power to produce the effect desired.
Elucidate—Explain ; make clear.
Emaciation—State of being reduced to leanness ; leanness.
Emetic—A medicine used to produce vomiting.
Entozoa—A sub-division of human parasites, comprising the hollow worms and solid worms.
Enunciated—Declared ; announced ; stated.
Environment—That which surrounds ; the conditions under which one lives.
Epidemic—A term for a popular, prevailing, but not native disease arising from a general and temporary cause (as excessive heat).
Epidermis—The outer skin.
Epilation—The act of removing hair.
Episcleral—Pertaining to the connective tissue which lies between the conjunctiva and sclerotic.
Epithelium—The superficial, insensible, and bloodless layer of the skin and mucous membrane.
Epizootic—A term applied to diseases which prevail among the lower animals, and corresponding with the term "endemic" as applied to man.
Eradicate—To pull up the roots, or by the roots ; to root out ; to destroy thoroughly.
Eruption—Disease affecting the skin.
Esophagus—The gullet, a musculo-membranous canal extending from the lower part of the pharynx to the superior orifice of the stomach. Also spelt *Œsophagus*.
Etiology—The doctrine of the causes or reasons of phenomena, hence, the doctrine of the causes of disease. Also spelt *Ætiology*.
Evaporation—Going off in the form of vapour.
Excrement—The refuse from the bowels ; dung ; manure.
Exigency—Pressing necessity ; urgency ; pressure ; emergency.
Ex officio—In virtue of his office.
Expiration—A breathing out.
Extirpation—Act of extirpating or rooting out ; eradication ; complete removal.
Exudate—Something exuded or oozed out (as moisture or other liquid) through pores or fine holes.

Febrile—Pertaining to fever ; indicating fever or derived from it.
Fermentation—Process of decomposition or conversion of substance into new compounds through the agency of a ferment. Generally indicated by a sensible internal motion, the development of heat, and the liberation of bubbles of gas.
Fetid—Foul smelling.
Fibrin—A constituent of muscle and of the blood.
Fibrous—Composed or consisting of fibres ; containing fibres.
Fistula—A pipe-like sore with a narrow orifice and without disposition to heal.

Foci—Plural of *focus.*
Focus—A central point or point of convergence.
Fœtal—Pertaining to the fœtus.
Fœtus—The young in the womb.
Follicle—A small cavity.
Formalin—A 40-per-cent. watery solution of formaldehyde gas which is a strong disinfectant.
Function—The particular use of an organ.
Fundamental—Serving as groundwork.
Furuncle—A superficial inflammatory tumour suppurating with a central core; a boil.

Genital—Pertaining to the organs of generation.
Germinate—To sprout; to bud; to shoot; to begin to vegetate or grow (as seeds).
Gestation—Carrying the young in the womb.
Gland—An organ secreting a fluid.
Glandular—Having the character of a gland; consisting of a gland or glands.

Hemolytic—Possessing the power of dissolving blood cells.
Hemorrhage—A bursting forth of blood; any discharge of blood from vessels destined to contain it.
Hemorrhagic—Pertaining to hemorrhage.
Hereditary—Transmitted from parent to offspring.
Heterogenous—Composed of dissimilar or incongruous parts or elements; miscellaneous. Opposed to *homogeneous*.
Histology—The science occupied with the investigation of the ultimate microscopic structure of the component parts of plants and animals without reference to the form or size of the parts which they compose.
Hydrarthroses—White swellings; dropsy of articulations from accumulations of fluids, partaking in various degrees of the character of sera and synovia. Generally occurring in the knee joint.
Hypodermic—Under the skin.
Hypothesis—A supposition or assumption; something not proved but assumed for the purpose of argument; a system or theory imagined or assumed to account for what is not understood.

Idiosyncrasy—Peculiarity of temperament or constitution; a mental or moral characteristic belonging to and distinguishing an individual.
Immunisation—The process of making immune; rendering proof against disease or poison.
Incipient—Beginning; commencing; beginning to make appearance.
Incision—A cut.
Incubation—Development of the life germ (as in an egg).
Indemnity—Compensation for loss, damage, or injury sustained.
Inertia—The property of matter by which it retains its state of rest or of uniform motion so long as no external cause occurs to change that state.
Infection—Transmission of disease.
Infiltration—The diffusion of fluids into the cellular tissues of organs. It may be serous, and is then termed "œdema" or "anasarca"; or sanguineous, and is then called "hemorrhage" and "apoplexy"; or purulent, occurring in the third stage of pneumonia; or tuberculous, either grey or gelatinous.
Ingestion—The process of taking food into the stomach.
Innocuous—Harmless; not injurious; producing no ill effect.
Inoculation—The act or practice of inoculating; communication of a disease by contagious matter introduced into the blood; implantation of a virus or other biological fluid or substance.
Insemination—Sowing in of seed.
Instillation—Act of instilling, infusing, or causing to be imbibed.
Interlobular—Between the lobules.
Intestine—The canal or tube that extends with convolutions from the stomach to the anus.
Intracerebral—Into the brain.
Intracutaneous—Into the skin.

Intradermic—Into the derma or true skin which lies under the epidermis and rete mucosum.

Intramammary—Into the milk gland or udder.

Intramuscularly—Into the muscle.

Intraperitoneal—Through the peritoneum, a membrane investing the internal surface of the abdomen and, more or less, all the viscera contained in it.

Intravenous—Into the blood stream.

Inunction—The act of anointing or besmearing.

In vacuo—In a vacuum, space devoid of air.

Invalidate—To render invalid ; to destroy the strength or validity of ; to deprive of force or effect.

Iodine—A non-metallic substance extracted from the ashes of seaweed and much used in medicine.

Lachrymal—Pertaining to the tears from the eye.

Lacteal—A vessel, or slender tube, of animal bodies for conveying the chyle, or milk-like fluid, from the alimentary canal.

Lactic acid—The acid of sour milk.

Lariat—A long cord or thong of leather with a noose ; used in catching horses, etc.

Laryngeal—Pertaining to the larynx.

Larynx—The upper portion of the windpipe or trachea.

Latency—State of being latent ; not visible or apparent : not manifested nor producing sensible effect.

Lecithin—A complex substance containing phosphorus and nitrogen. It is found in the brain, nerves, yolk of egg, etc.

Lesion—Any injury or unhealthy change in the exercise of functions or the texture of an organ.

Leucocyte—A white cell ; a white corpuscle of the blood.

Ligature—Thread or silk or inkle, commonly rubbed with white wax, for tying arteries, excrescences, etc.

Lobe—A round projecting part of something, such as part of the liver, lungs, brain, etc.

Longitudinal—Pertaining to longitude ; running lengthwise as distinguished from transverse, or across.

Lumbar—Pertaining to the loins.

Lymph—A colourless fluid in animal bodies contained in certain vessels called lymphatics.

Lymphatic—Pertaining to lymph ; conveying lymph. The term is also applied to the vessels which convey the lymph. These are capillary tubes which pervade almost every part of the body, from which they absorb or take up lymph.

Lymphatic ganglion—A conglobate gland ; a gland of a globular form without cavity or excretory duct.

Malaise—State of being ill at ease ; morbid and indefinite feeling of uneasiness.

Mammal—An animal that suckles its young.

Mammalian—Pertaining to mammals.

Mastitis—Inflammation, acute and chronic, of the substance of the mamma, that is, the organ which secretes the milk.

Maxilla—The jawbone.

Mediastinal—Pertaining to the mediastinum.

Mediastinum—A membranous partition dividing the thorax into the lateral cavities and distinguished into the anterior, the middle, and the posterior portions.

Melanotic—Pertaining to melanosis, a disease in which tissue is converted into a black, hard substance, near which ulcers may form.

Membrane—A thin flexible skin or texture occurring in various parts of animal bodies ; a similar texture in plants.

Menthol—A white crystalline substance obtained from oil of peppermint. Used externally in cases of nervous headache.

Mesentery—The membrane which suspends the small intestines from the posterior wall of the abdomen ; a reflection of the peritoneum.

Micrococcus—A microscopic organism of round form.

Millimetre—The thousandth part of a metre. Equal to ·03937 of an inch. The small letters in this type are a hairsbreadth more than a millimetre high.
Minimal—The least quantity assignable in a given case; the smallest amount or degree.
Mollusc—An animal whose body is soft, and which belongs to the sub-kingdom Mollusca, including animals usually provided with a shell, as mussels, oysters, land and sea snails, etc., as well as the cuttle fishes.
Morbid—Unhealthy.
Morphological—Pertaining to morphology, that department of biological science which treats of the form and arrangement of the structure of plants and animals; the science of form in the organic world.
Mucous—The membrane lining such cavities in the body that communicate with the outside.
Mucus—A fluid secreted by the mucous membrane.

Nasal—Pertaining to the nose.
Necrosis—Mortification.
Nil nocere—Never injuring, never to injure.
Node—A knot; an entanglement; a knob; a sort of knot or thickening on a stem.
Nodule—A little knot.
Nomenclature—The vocabulary of names or technical terms which are appropriated to any branch of science.
Normal—Natural; healthy.
Nutrition—Nourishment; the act or process by which plants or animals absorb their proper food.

Ocular—Pertaining to the eye or eyes; depending on the eye; received by actual sight.
Œdematous—Affected with œdema, a puffiness or swelling of parts arising from collection of water.
Œstrum—The period of sexual heat.
Oleic—A fatty acid contained in many liquid oils, notably olive and almond oils.
Opacity—State or quality of being opaque; impervious to the rays of light; not transparent.
Ophthalmic—Pertaining to the eye.
Opsonin—According to Sir A. Wright, the fluids of the blood so act upon the invading bacteria as to render them more easily ingested by the phagocytes. The substances in the blood which so act are formed by opsonins.
Oscillation—The act or state of oscillating or swinging backward and forward; the motion of a pendulum.
Oxytuberculin—Tuberculin with which oxygen has been combined.

Palpation—The act of feeling; manual examination.
Pancreas—The digestive gland which secretes the pancreatic fluid, the sweetbread.
Papule—A small pimple.
Parasite—A creature which lives on another living organism.
Parasitic—Belonging to a parasite; growing as a parasite grows; living on some other body.
Parenchyma—A name for certain tissues of animals and plants; the spongy and cellular tissue; the pulp of plants.
Paroxysmal—Caused by paroxysms or fits; convulsive; spasmodic; with a sudden and violent access of feeling.
Parturition—The act of bringing forth young.
Pasteurisation—The operation of Pasteurising. Pasteur showed that by heating liquids to certain temperatures below that of boiling water most bacteria were killed and the keeping property of the liquid thereby prolonged.
Pathogenic—Causing disease.
Pathological—Pertaining to pathology, the science of the nature, causes, and symptoms of disease.
Pediatrist—One skilled in pediatrics, the science of diseases of children.
Pellicle—A thin skin or film on a surface.

Percutaneous—Through the skin.
Peristaltic—The worm-like contractions of the intestines upon themselves, in successive circles, by means of which their contents are forced onwards.
Peritoneal—Pertaining to the peritoneum, a membrane investing the internal surface of the abdomen and, more or less, all the viscera contained in it.
Phagocyte—The name given to those leucocytes which have the power of enclosing bacteria and destroying or feeding on them.
Pharynx—The cavity at the back of the mouth.
Phenomenon—An appearance ; anything visible ; an appearance whose cause is not immediately obvious ; something extraordinary. When more than one is referred to the plural word *phenomena* is used.
Photophobia—Avoidance of light.
Phthisical—Having or belonging to phthisis.
Phthisis—A wasting disease of the lungs commonly known by the name of consumption.
Physiological—Pertaining to physiology, the study of the functions of living beings.
Pigmentation—The act or state of becoming pigmented, that is, charged with pigment (colouring matter) ; discoloration.
Placenta—The afterbirth.
Pledget—A compress or small flat mass of lint laid over a wound.
Pleura—The covering of the lungs.
Plural—See definition of *Phenomenon*.
Polynuclear—Containing many nuclei, the germs of cells.
Post fœtal—After birth.
Post mortem—After death.
Pregnant—Carrying the young.
Prerequisite—Previously requisite ; necessary to something subsequent.
Primâ facie—At first view or consideration.
Procedure—Act or manner of proceeding ; course of action.
Proclivity—Inclination ; propensity ; tendency.
Progenitor—A forefather ; an ancestor in the direct line.
Prognosticate—To foretell.
Proliferation—The invasive spreading mode of bacterial growth in the tissues.
Promiscuous — Confused ; indiscriminate ; miscellaneous ; consisting of individuals mixed up in a body or mass without order.
Propagation—Act of propagating ; the continuance or multiplication of the kind by generation or reproduction ; diffusion.
Prophylaxis—A term denoting the use of precautionary measures in the treatment of disease, the attempt, that is, to cure the disease before its reality is demonstrated.
Pulmonalis—Pertaining to the lungs.
Pulmonary—Pertaining to the lungs.
Purulent—Consisting of or containing pus, or matter.
Pus—Mattery fluid.
Pustules—Pimples containing pus.
Pylorus—The opening from the stomach to the intestines.
Pyogenes—Generating pus.

Quarantine—The period (originally of forty days, now of variable length) during which a ship arriving in port and suspected of being infected with a malignant contagious disease is obliged to forbear all intercourse with the place ; a state of somewhat similar isolation.
Quiescent—Being in a state of rest or repose ; still ; tranquil ; not active.

Receptivity—The quality or state of being receptive, such as to receive readily ; taking in ; able to take in, hold, or contain.
Recrudescence—Renewed outbreak.
Rectum—The latter part of the bowels.
Regime—Mode or system of management ; administration ; rule.
Reimbursement—Act of reimbursing ; repayment.
Respiration—Breathing.
Retrogressive—Going or moving backward ; declining to a less perfect state.
Revolutionised—Radically changed.

Ricin—A poisonous albuminoid in castor bean.
Rinderpest—A most virulent contagious disease affecting ruminant animals, especially cattle.
Ruminant—An animal which chews the cud.
Rumination—The act of chewing the cud.

Saliva—A fluid secreted into the mouth by the salivary glands.
Salivation—Excessive flow or secretion of saliva, as that produced by mercury; ptyalism.
Sanitary—Such as to promote health.
Sanitation—Methods of making sanitary.
Scarify—To make small superficial incisions in the skin so as to draw blood without opening a large vein.
Scours—Violent purgings.
Secrete—To separate from the blood.
Septic—Promoting or causing putrefaction.
Septicæmia—Contamination of the blood with micro-organisms which rapidly multiply in the system with the production of high fever.
Serous—Like water.
Serum—The watery part of curdled milk; whey; the thin, transparent part of the blood, or any similar fluid.
Spherical—Having the form of a sphere or ball.
Spontaneous—Acting by its own impulse; not arising through external influence; growing or springing up naturally.
Sporadic—Occurring here and there in a scattered manner.
Staphylococcus—A round micro-organism which grows in irregular masses. Plural, *Staphylococci*.
Statistics—Any systematic statement of facts brought out by collecting numbers.
Sterile—Incapable of reproduction; free from living material.
Stimulus—That which incites to action or exertion.
Stratification—The process of stratifying or state of being stratified; arrangement in strata or layers.
Streptococcus—A round micro-organism which grows in chains.
Subcaudal—Under the tail.
Subcutaneous—Under the skin.
Sublumbar—Under the small of the back.
Superinfection—An additional infection implanted into an organism already infected.
Supernatant—Swimming above; floating on the surface.
Suppuration—The process or state of suppurating or producing pus, as in a wound or abscess.
Supramammary—Above the mamma.
Symptom—An outward sign.
Syphilis—A contagious and hereditary venereal disease.

Tabes mesenterica—Tuberculous disease of the mesenteric glands.
Tampon—A plug for insertion into a natural or artificial cavity of the body for arresting hemorrhage.
Technique—Method of manipulation in any art.
Therapeutics—That part of medicine which deals with the application and operation of remedies.
Thermal—Pertaining to heat or its phenomena.
Thesis—A position or proposition which a person advances and offers to maintain.
Thoracic—Pertaining to or contained in the thorax, that part of the human body which contains the lungs, heart, etc.; the chest; the corresponding portion of lower animals.
Thorax—The chest.
Toxin—A poisonous compound containing nitrogen, either of animal nature (as snake poison), vegetable origin (as ubrin from jequirity), or bacterial origin (as tuberculin).
Trachea—The windpipe.
Transcutaneous—Through the skin.
Traumatic—Pertaining to or applied to wounds; a medicine useful in the cure of wounds.

Trimethylamine—A substance resembling ammonia gas.
Tumefaction—The act of swelling or rising into a tumour ; a swelling.
Typus bovinus—Of the bovine type.
Typus humanus—Of the human type.

Ubiquitous—Existing or being everywhere.
Ultramarine—A beautiful and durable sky blue formed of the mineral lapis lazuli.
Umbilical—Pertaining to the navel or something resembling a navel.
Uterus—The womb.
Utilisation—Making useful ; putting into use.

Vacillating—Inclined to waver.
Vagina—The passage leading from the womb.
Vascular—Pertaining to those vessels or tubes of animals or plants that belong to the circulatory system, or have to do with conveying blood, chyle, etc.
Venous—Pertaining to the veins (venous blood as distinguished from arterial blood).
Vermicular—Resembling the motion of a worm.
Vertebra—The backbone.
Vesicular—Pertaining to or consisting of vesicles ; full of vesicles, cellular in structure.
Virulence—Quality of being virulent ; poisonous or extremely noxious character ; malignity.
Virus—Contagious poisonous matter (as of small-pox, hydrophobia, etc.).
Viscera—The entrails ; the bowels.

Xylol—A colourless, volatile liquid, resembling coal-tar benzene.

Zymotic—Caused by a germ.

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